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AFFDL-TR-69-43
VOLUME II

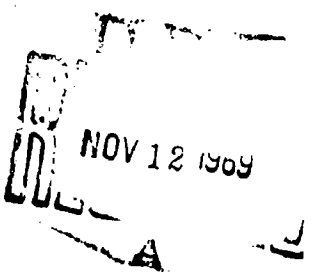
INVESTIGATION OF JOINTS IN ADVANCED FIBROUS COMPOSITES FOR AIRCRAFT STRUCTURES

JOINT AND ATTACHMENT INVESTIGATION
VOLUME II. TEST RESULTS

G. M. Lehman
A. V. Hawley
et al.

TECHNICAL REPORT AFFDL-TR-69-43, VOLUME II

JUNE 1969



Structures Division
Air Force Flight Dynamics Laboratory
Wright-Patterson Air Force Base, Ohio

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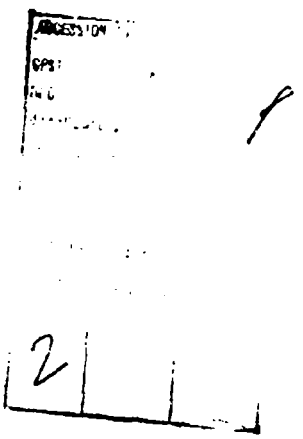

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INVESTIGATION OF JOINTS IN ADVANCED FIBROUS COMPOSITES FOR AIRCRAFT STRUCTURES

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G. M. Lehman
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FOREWORD

This report was prepared by the McDonnell Douglas Corporation, Douglas Aircraft Company, Long Beach, California, under the terms of Air Force Contract F33615-67-C-1582. It is the final report of work completed between 25 April 1967 and 28 March 1969. The contract was administered by the Structures Division, Air Force Flight Dynamics Laboratory (AFFDL). Mr. Elden E. Zink was the Program Manager for AFFDL.

The project was conducted under the direction of Mr. G. E. Anderson, Director of Structural Engineering, Mr. D. G. Smillie, Supervisor of Structural Development and Advanced Design in the Structural Engineering Section, and Mr. D. S. Warren, Supervisor of Research and Development/ Analysis Methods in the Structural Mechanics Section. Mr. G. M. Lehman of the Structural Engineering Section was Technical Director. The following Douglas personnel were the principal contributors to the program:

Mr. A. V. Hawley, Structural Design and Weight Analysis

Mr. W. J. Richards and Dr. R. Teodosiadis, Discrete Element Structural Analysis

Mr. M. Ashizawa, Analysis of Parametric Trends

Mr. R J. Palmer, Materials Research and Process Engineering

Mr. M. Marcoux and Mr. D. E. McCay, Instrumentation and Testing

The manuscript was released for publication in June 1969. The report was prepared under Douglas Report DAC-68498.

This technical report has been reviewed and is approved.

Philip A. Parmley
Chief, Advanced Composites Branch
Structures Division

ABSTRACT

Engineering drawings, experimental data, and quality control data are presented in this volume for specimens that were tested in an investigation of joints and attachments in advanced fibrous composites for aircraft structures. Engineering drawings are presented showing design details and parametric variations for each specimen. Test fixture and instrumentation details are shown for a trosion ring adhesive shear test apparatus designed to measure stress-strain characteristics of adhesives in pure shear without the stress concentrations of conventional lap shear specimens. Experimental plots or test data tabulations are presented for basic laminate and adhesive properties and for static and fatigue strength tests on bonded and bolted joint specimens. Laminate properties are presented for boron and fiber glass-reinforced epoxy resin composites under tension, compression, in-plane shear, interlaminar shear, and pin-bearing loads. Test results are summarized for six adhesives in lap joint shear, flatwise tension on a honeycomb core, and in pure shear in the torsion ring test. Static test results are given for adhesive joint specimens (single and double lap, scarf, stepped lap, and variable stiffness) using Shell 951 adhesive (and AF130 in selected joints), and for single-fastener, bolted joint specimens (single and double lap, composite-reinforced steel shim-reinforced, and bushed hole) using 0.19- or 0.250-inch-diameter bolts. Test results are tabulated for selected joint concepts under constant-amplitude fatigue test conditions. Quality control specifications, incoming inspection records, and resin and void content determinations are presented. The vacuum pyrolysis method of determining the resin content by boron-epoxy laminates is described.

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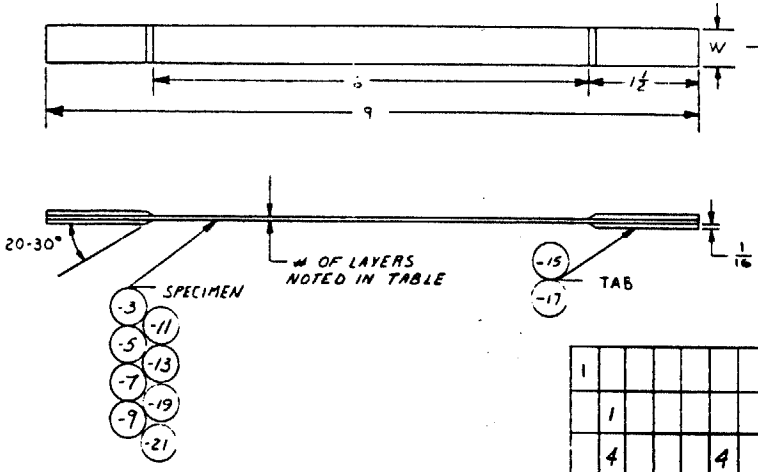
ENGINEERING DATA TESTS



REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED
A	REVISED -7 & -9, ADDED -5 & -13	7/1/68	[illegible]

GENERAL NOTES: UNLESS OTHERWISE NOTED

1. IDENTIFY PER DPS 3.02
2. PREPARE TAB ENDS FROM A CURED LAMINATE OF 0/90° 'S' GLASS 1/16" THICK
3. BOND TAB ENDS USING NARMCO 252 ADHESIVE. CURE 90 MINUTES AT 250°

-513	-511	-509	-607	-505	-503	-501	-1	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	STOCK SIZE	MATERIAL DESCRIPTION	MATERIAL SPECIFICATION	FIND NO.	QTY
							1	-21	SPECIMEN		NOTED	SURAN	DMS 1919		
								-19	SPECIMEN		NOTED	SURAN	DMS 1919		
						4		-17	TAB		1/16 x ½ x 1½	BONDED SCOTCHPLY S-GLASS			
4		4	4	4		4	4	-15	TAB		1/16 x 1 x 1½				
		1						-13	SPECIMEN		NOTED	HTS GLASS	S-994		
			1					-11							
				1				-9							
					1			-7							
						1		-5				BORON	DMS 1919		
							1	-3							

QUANTITY REQUIRED PER NOTED ASSY

LIST OF MATERIALS

DASH NUMBERS OF THIS DRAWING USE DASH NUMBERS SHOWN
EVEN DASH NUMBERS OPPOSITE

FINISH

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES.
TOLERANCES
FRACTIONS ± 1/32
DECIMALS ± .015
ANGLES ± 1/2°

MATL		
WT CHK		
STR CHK		
CHECK	SPRINKMAN	2/27/68
PR ENGR	[illegible]	2/15/68
DES ENGR	[illegible]	2/16/68
QR ENGR	[illegible]	
PREP BY	COMMERENSE	2-16-68

DOUGLAS AIRCRAFT COMPANY, INC. LONG BEACH, CALIFORNIA

SPECIMEN ASSY — COMPOSITE TENSILE TEST

FIRST RELEASE OF PRINTS: FEB 20 1968
ORIGINAL DATE OF DRAWING: FEB 2 1968

DESIGN ACTIVITY APPROVAL

CUSTOMER APPROVAL

CODE IDENT NO. 88277 | SIZE C | Z4824842

SCALE 1/1 | SHEET 1 OF

SEE ENGINEERING RECORDS FOR USAGE DATA

LAYUP OF SPECIMENS

	LAYUP ANGLE ø							
SPECIMEN	-3	-5	-7	-9	-11	-13	-19	-21
W	1	1	½	1	1	1	½	1
LAYER 1	0	0	0	90	0	0	0	90
2	45	45	0	90	45	45	0	90
3	-45	-45	0	90	-45	-45	0	90
4	0	90		90	0	[illegible]	0	90
5	[illegible]	90		90	0	90	0	90
6	-45	-45			-45	-45	0	90
7	45	45			45	45		90
8	0	0			0	[illegible]		90
9								90
10								90

DRAWING Z4824842. SPECIMEN ASSEMBLY – COMPOSITE TENSILE TEST

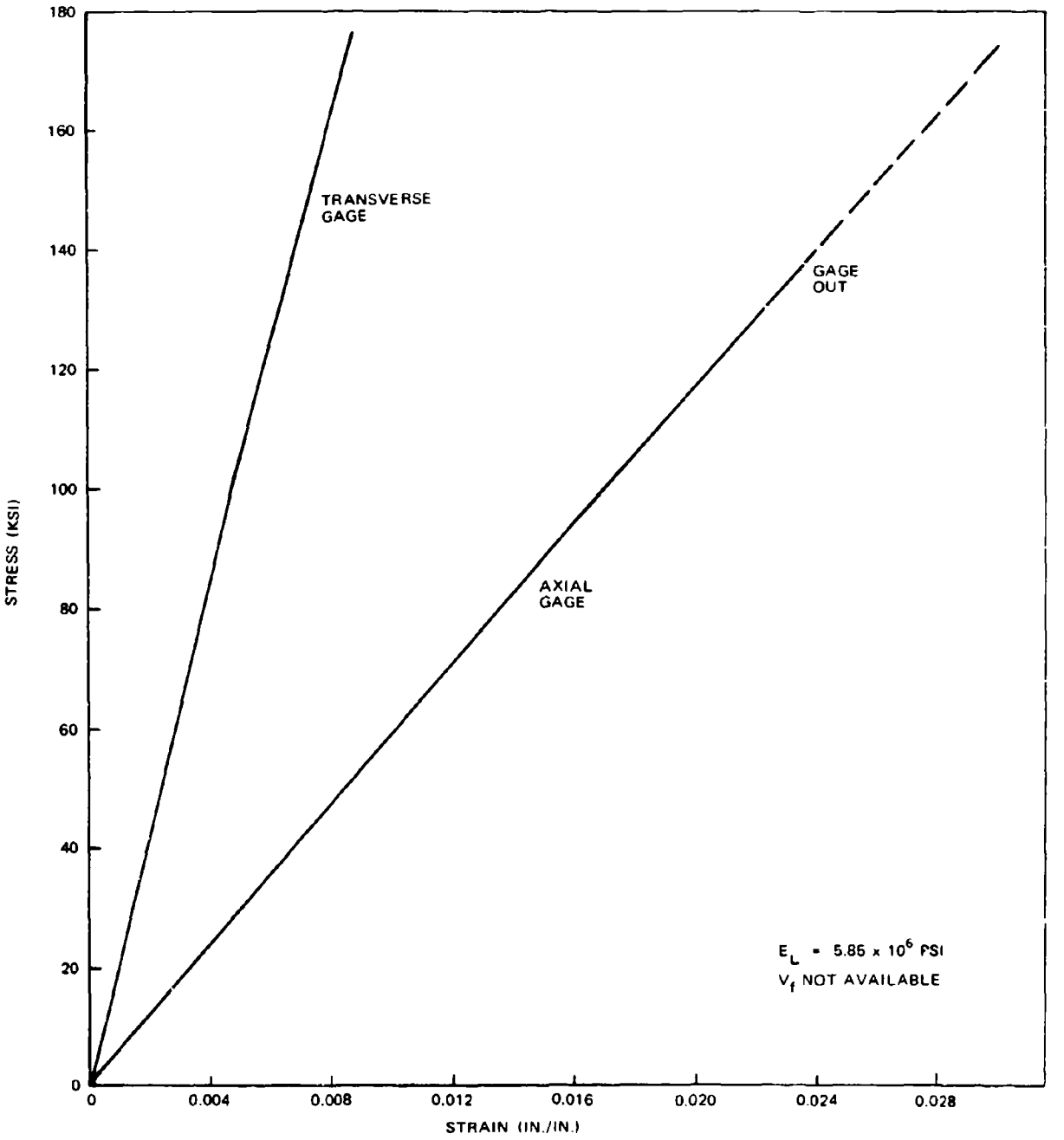


FIGURE 1. TENSILE STRESS-STRAIN DIAGRAM FOR LONGITUDINAL, UNIDIRECTIONAL S-994 FIBER GLASS-NARMCO 5505 LAMINATE (a)

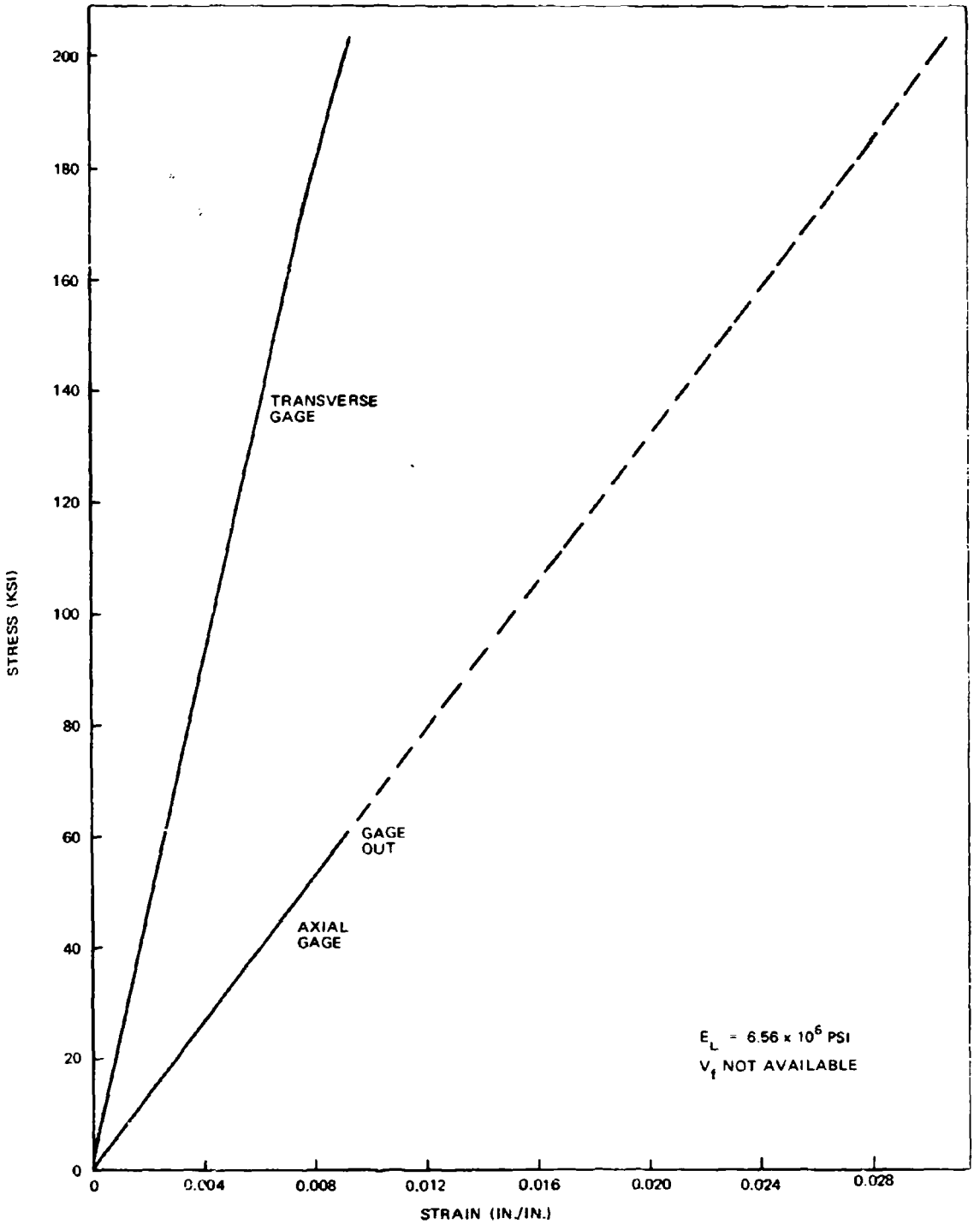


FIGURE 2. TENSILE STRESS-STRAIN DIAGRAM FOR LONGITUDINAL, UNIDIRECTIONAL S-994 FIBER GLASS-NARMCO 5505 LAMINATE (b)

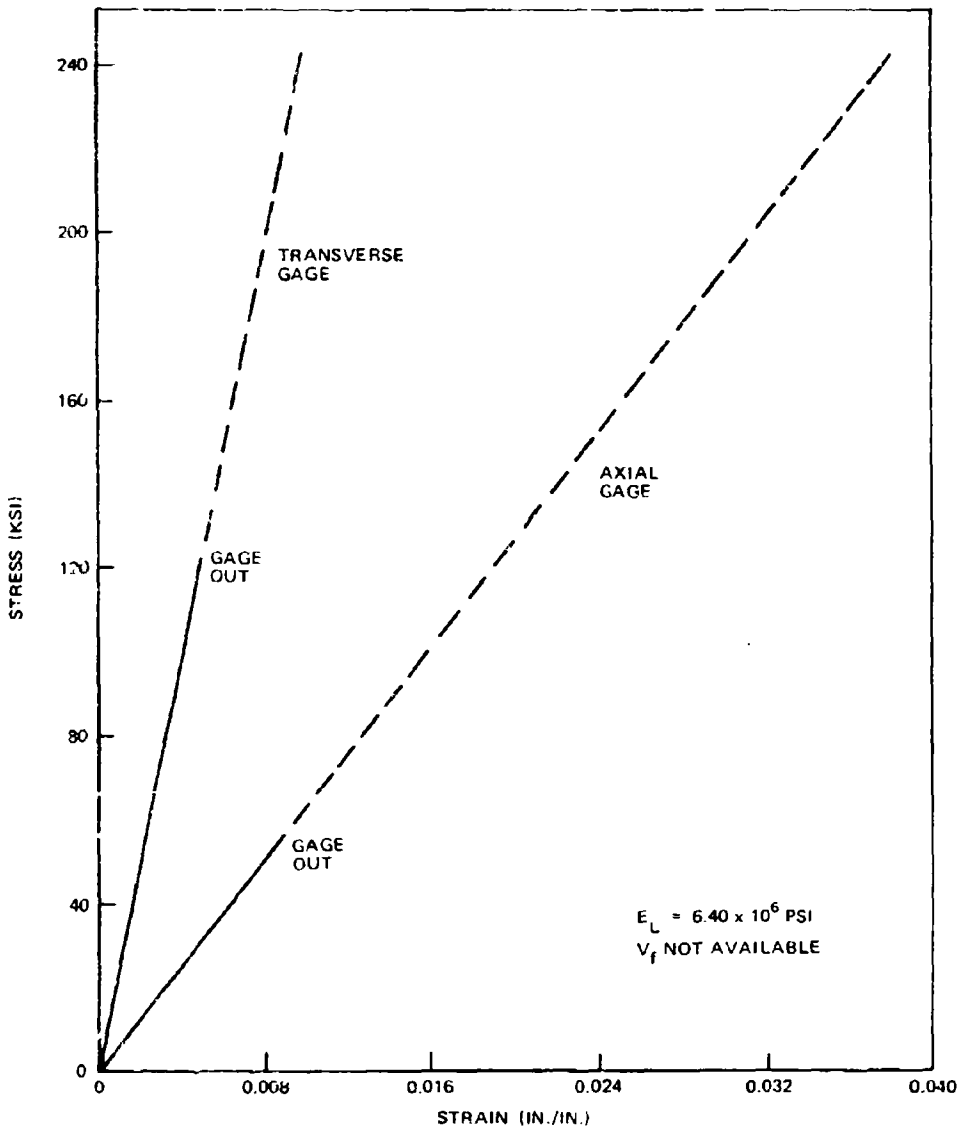


FIGURE 3. TENSILE STRESS-STRAIN DIAGRAM FOR LONGITUDINAL, UNIDIRECTIONAL S-994 FIBER GLASS-NARMCO 5505 LAMINATE (c)

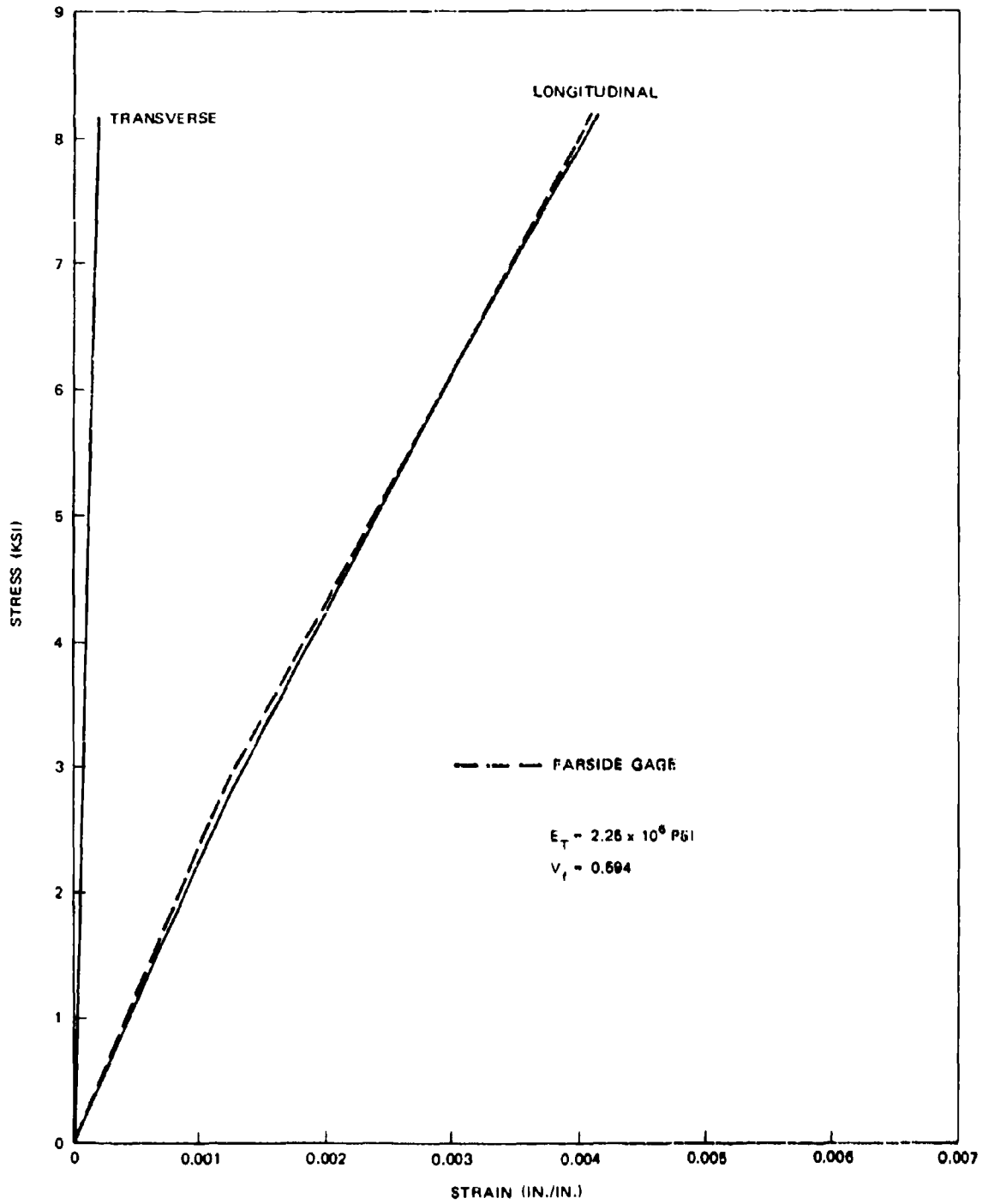


FIGURE 4. TENSILE STRESS-STRAIN DIAGRAM FOR TRANSVERSE, UNIDIRECTIONAL S-994 FIBER GLASS-NARMCO 5505 LAMINATE (a)

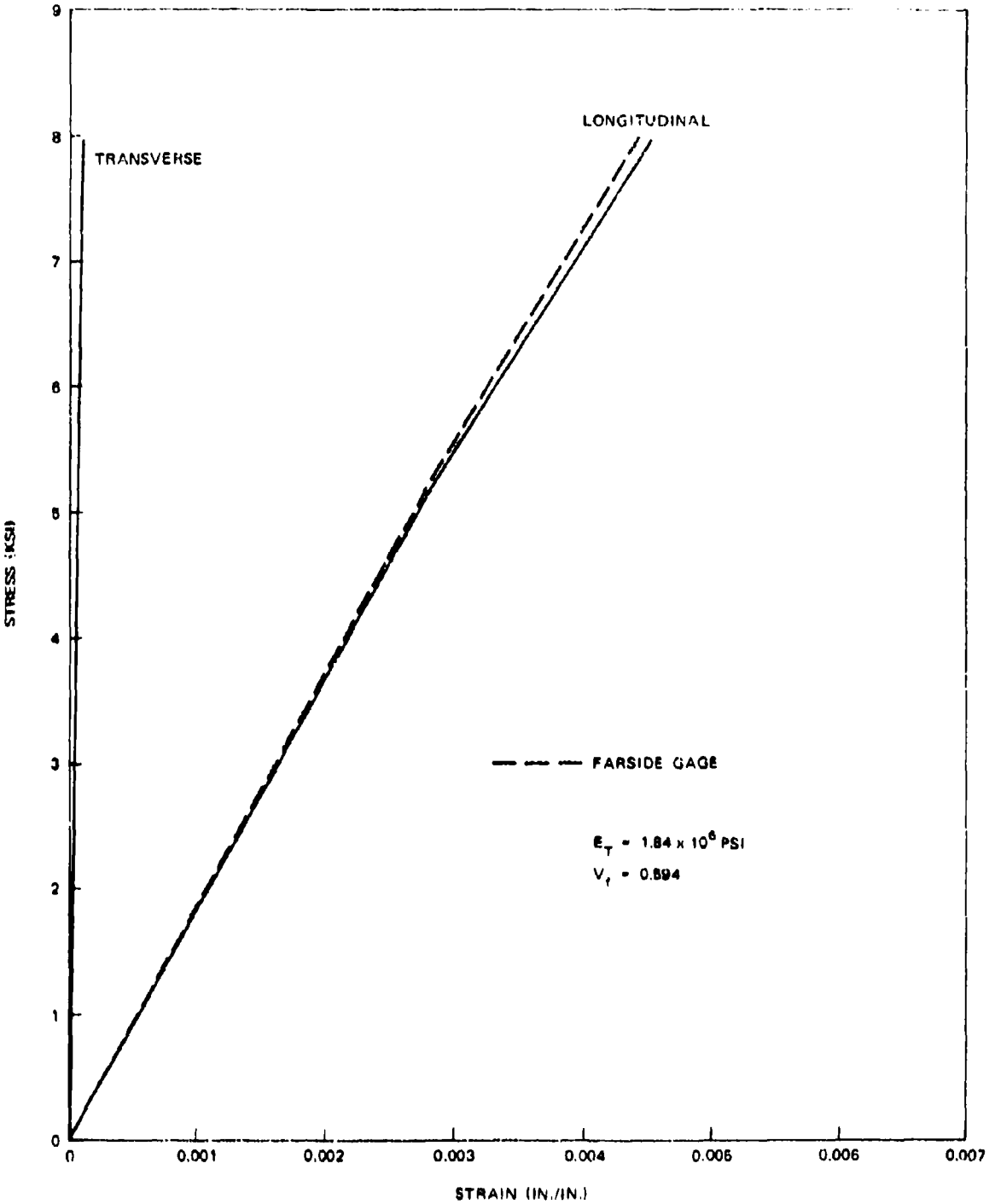


FIGURE 5. TENSILE STRESS-STRAIN DIAGRAM FOR TRANSVERSE, UNIDIRECTIONAL S-994 FIBER GLASS-NARMCO 5505 LAMINATE (b)

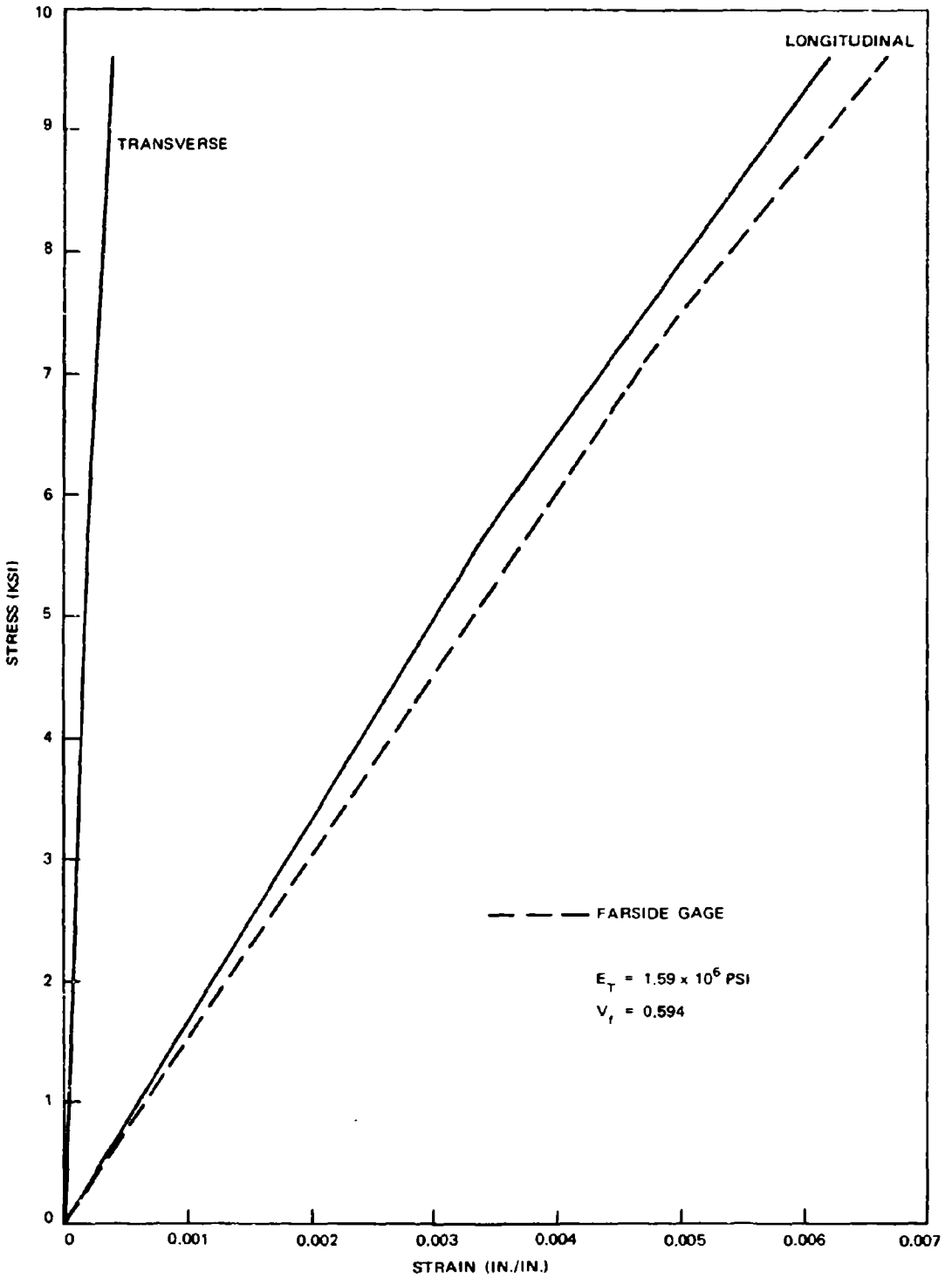


FIGURE 6. TENSILE STRESS-STRAIN DIAGRAM FOR TRANSVERSE, UNIDIRECTIONAL S-994 FIBERGLASS-NARMCO 5505 LAMINATE (c)

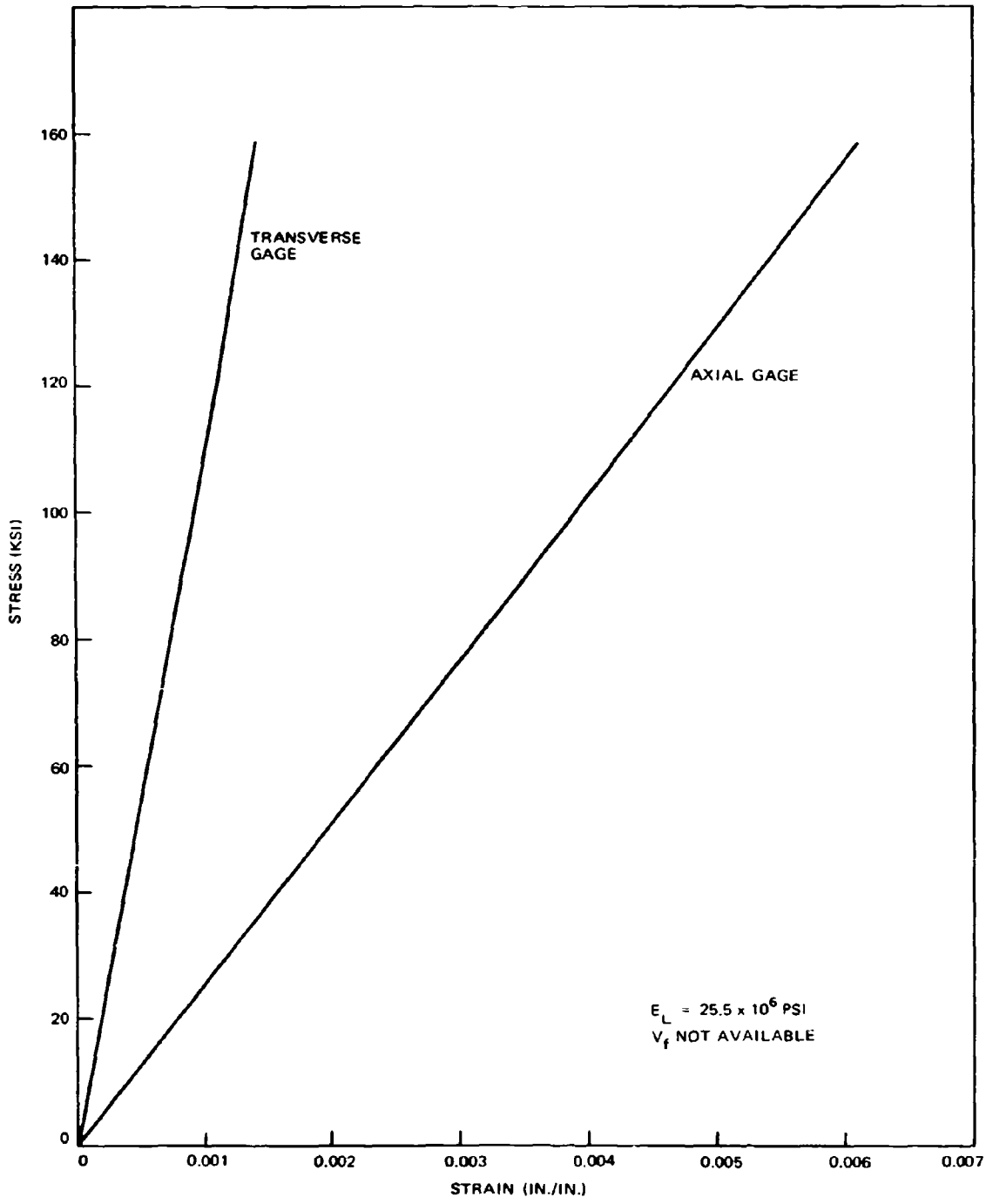


FIGURE 7. TENSILE STRESS-STRAIN DIAGRAM FOR LONGITUDINAL, UNIDIRECTIONAL BORON-NARMCO 5505 LAMINATE (a)

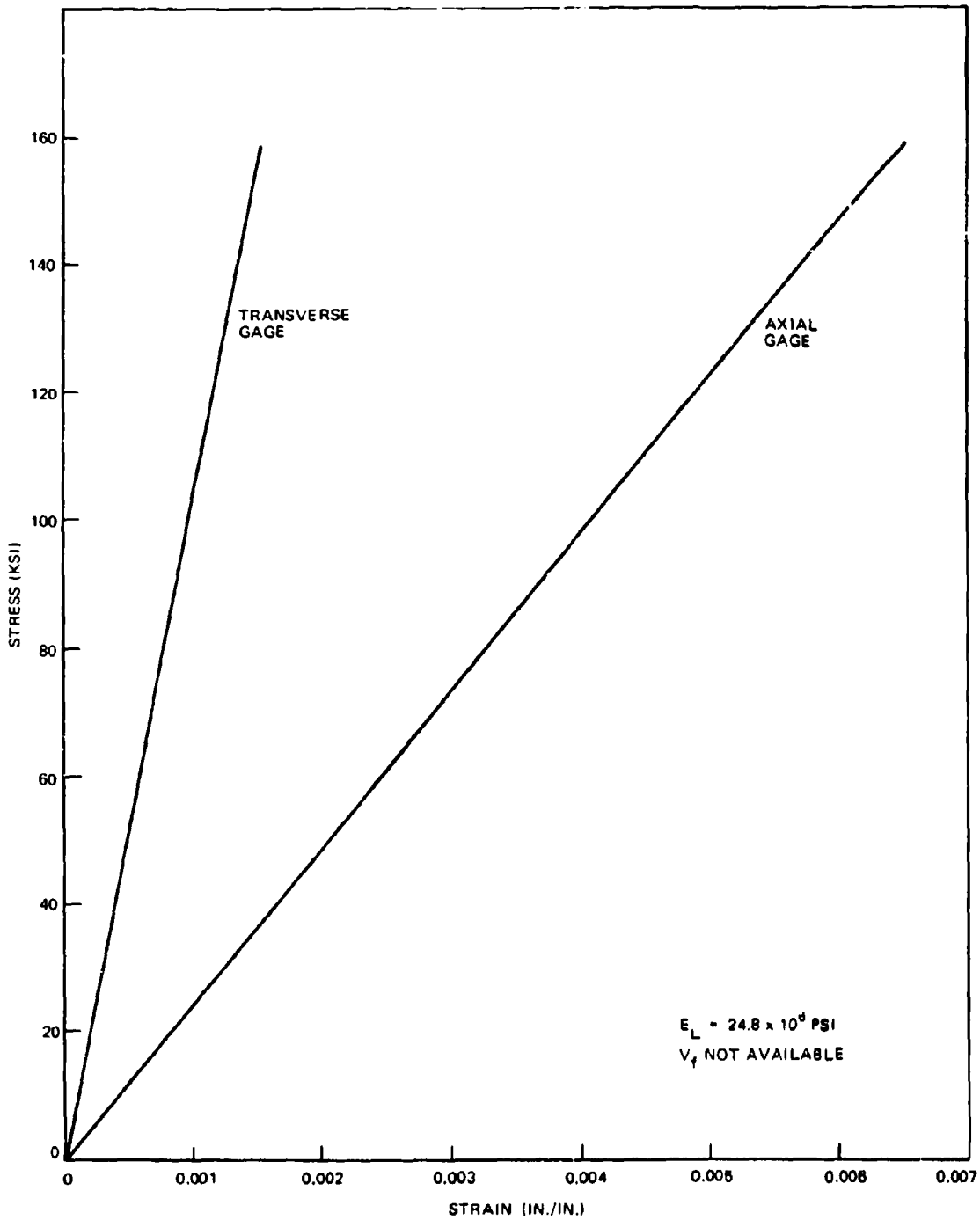


FIGURE 8. TENSILE STRESS-STRAIN DIAGRAM FOR LONGITUDINAL, UNIDIRECTIONAL BORON-NARMCO 5505 LAMINATE (b)

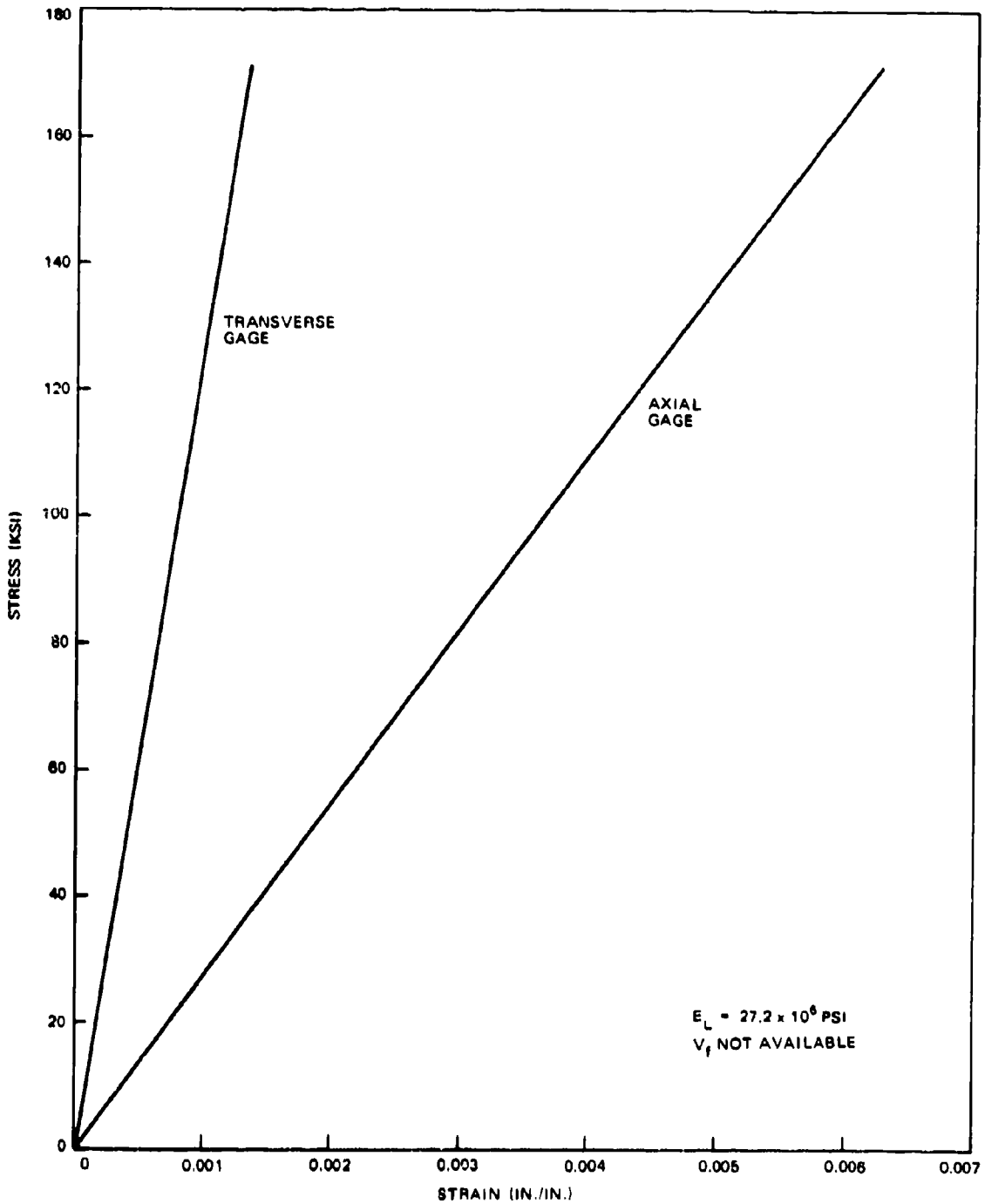


FIGURE 9. TENSILE STRESS-STRAIN DIAGRAM FOR LONGITUDINAL, UNIDIRECTIONAL BORON-NARMCO 5505 LAMINATE (a)

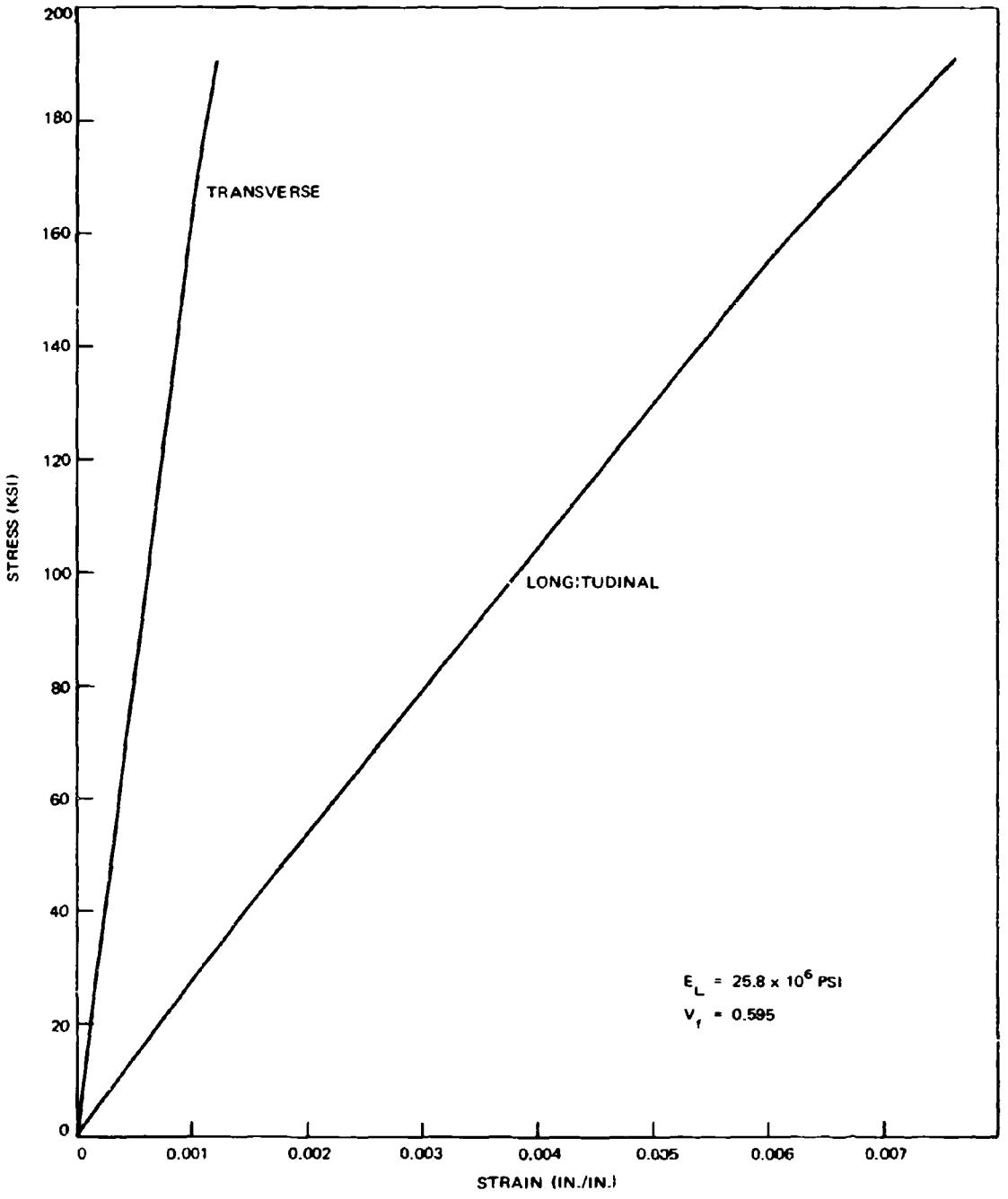


FIGURE 10. TENSILE STRESS-STRAIN DIAGRAM FOR LONGITUDINAL, UNIDIRECTIONAL BORON-NARMCO 5505 LAMINATE (d)

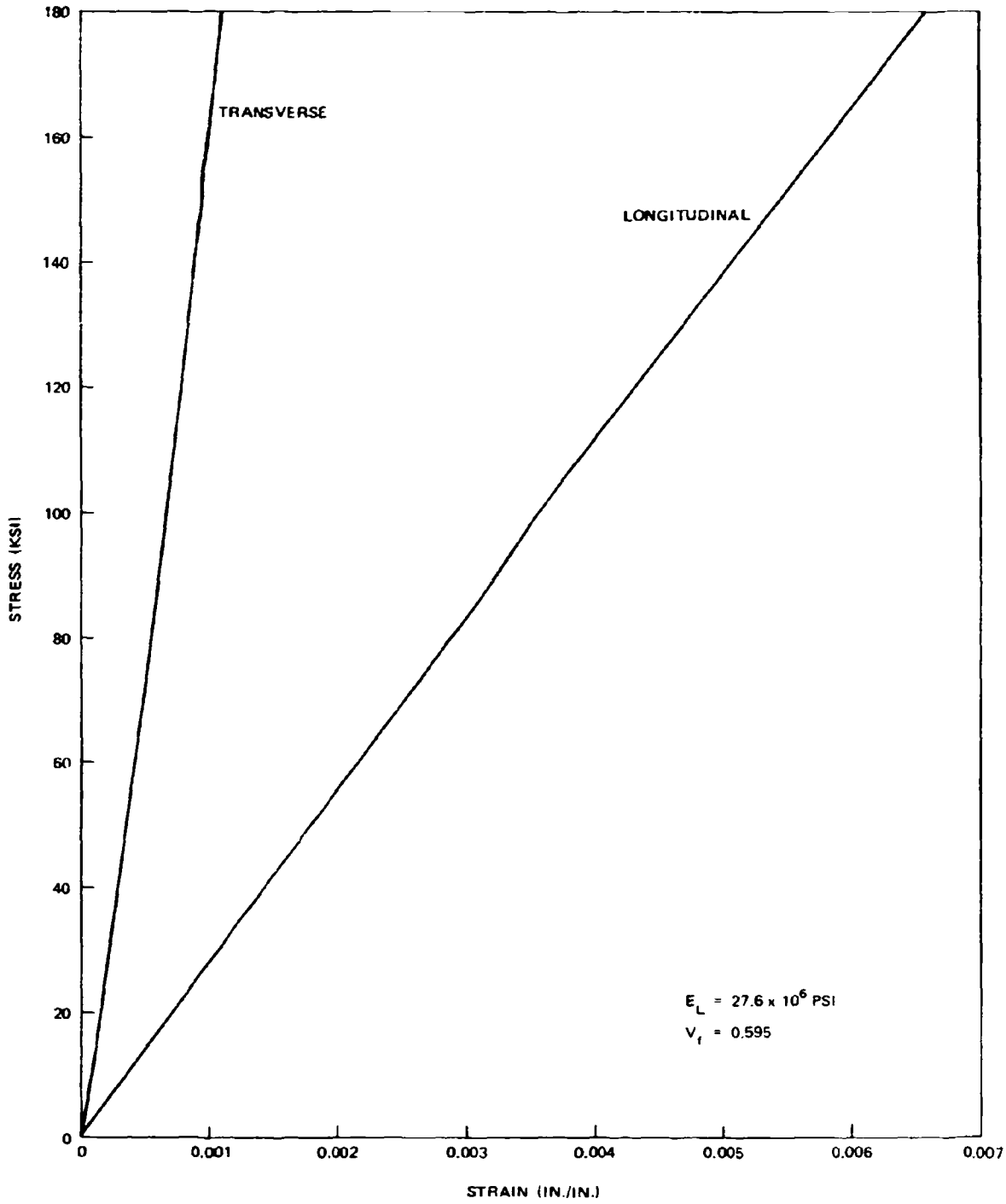


FIGURE 11. TENSILE STRESS-STRAIN DIAGRAM FOR LONGITUDINAL, UNIDIRECTIONAL BORON-NARMCO 5505 LAMINATE (e)

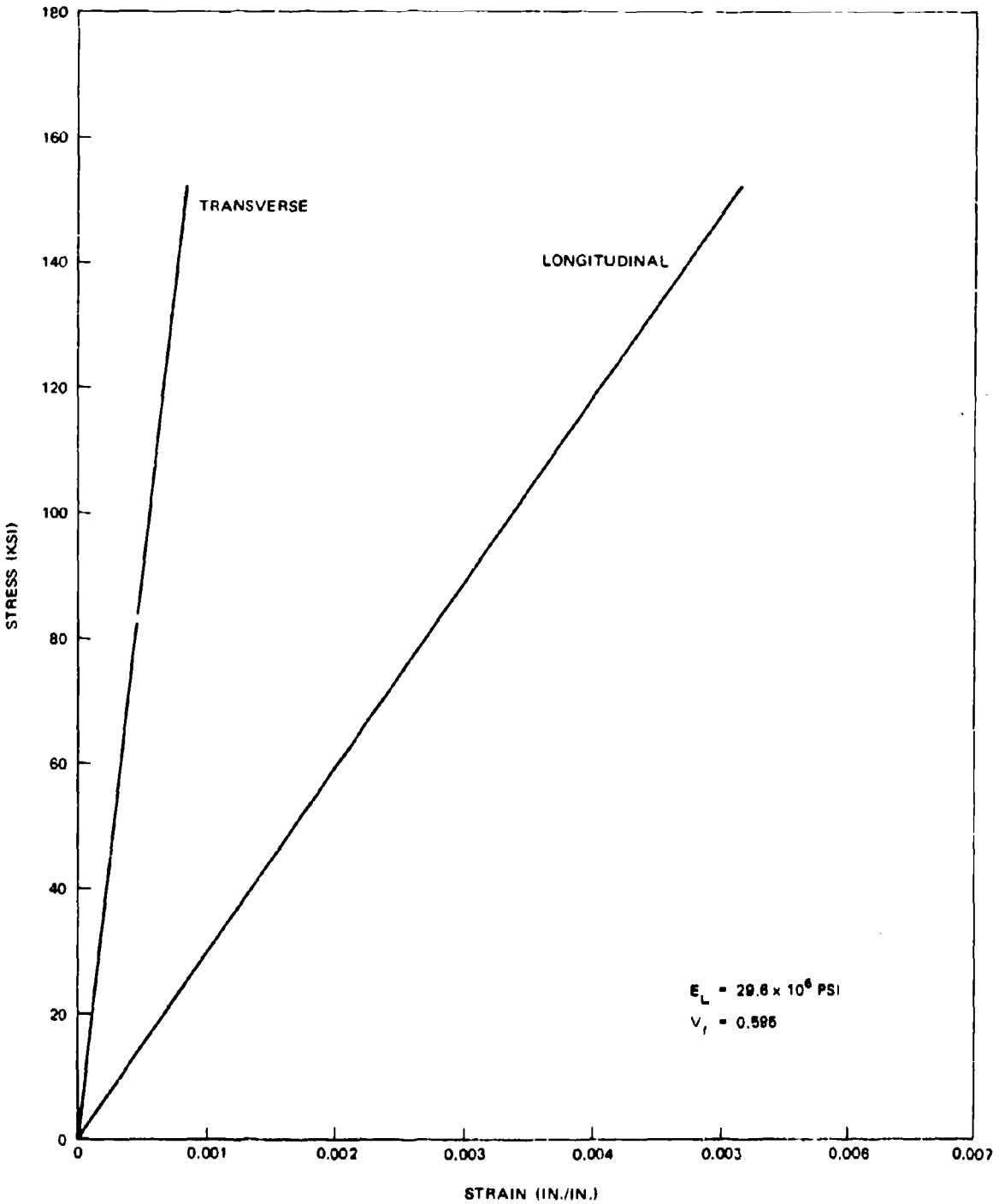


FIGURE 12. TENSILE STRESS-STRAIN DIAGRAM FOR LONGITUDINAL, UNIDIRECTIONAL BORON-NARMCO 5505 LAMINATE (f)

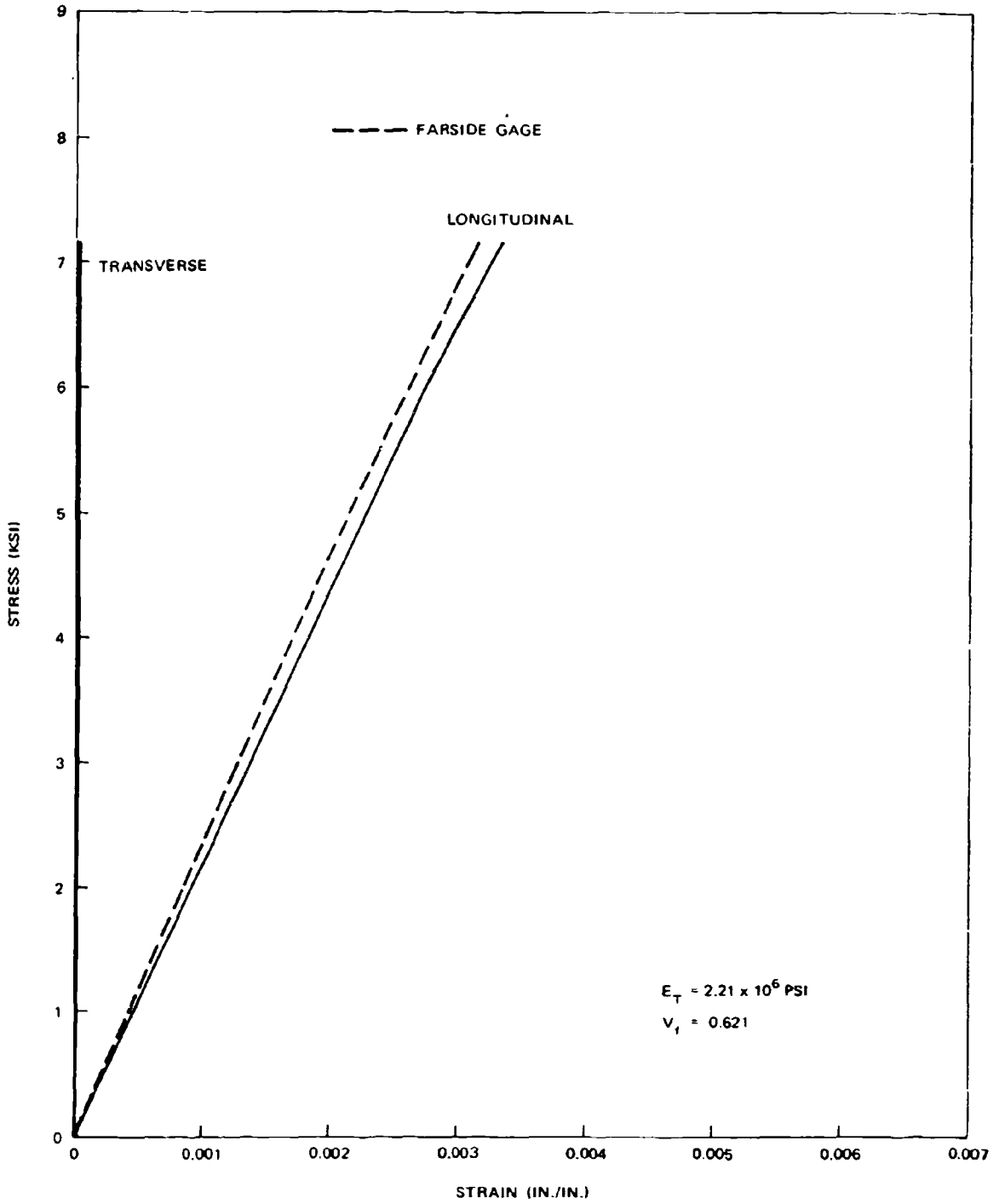
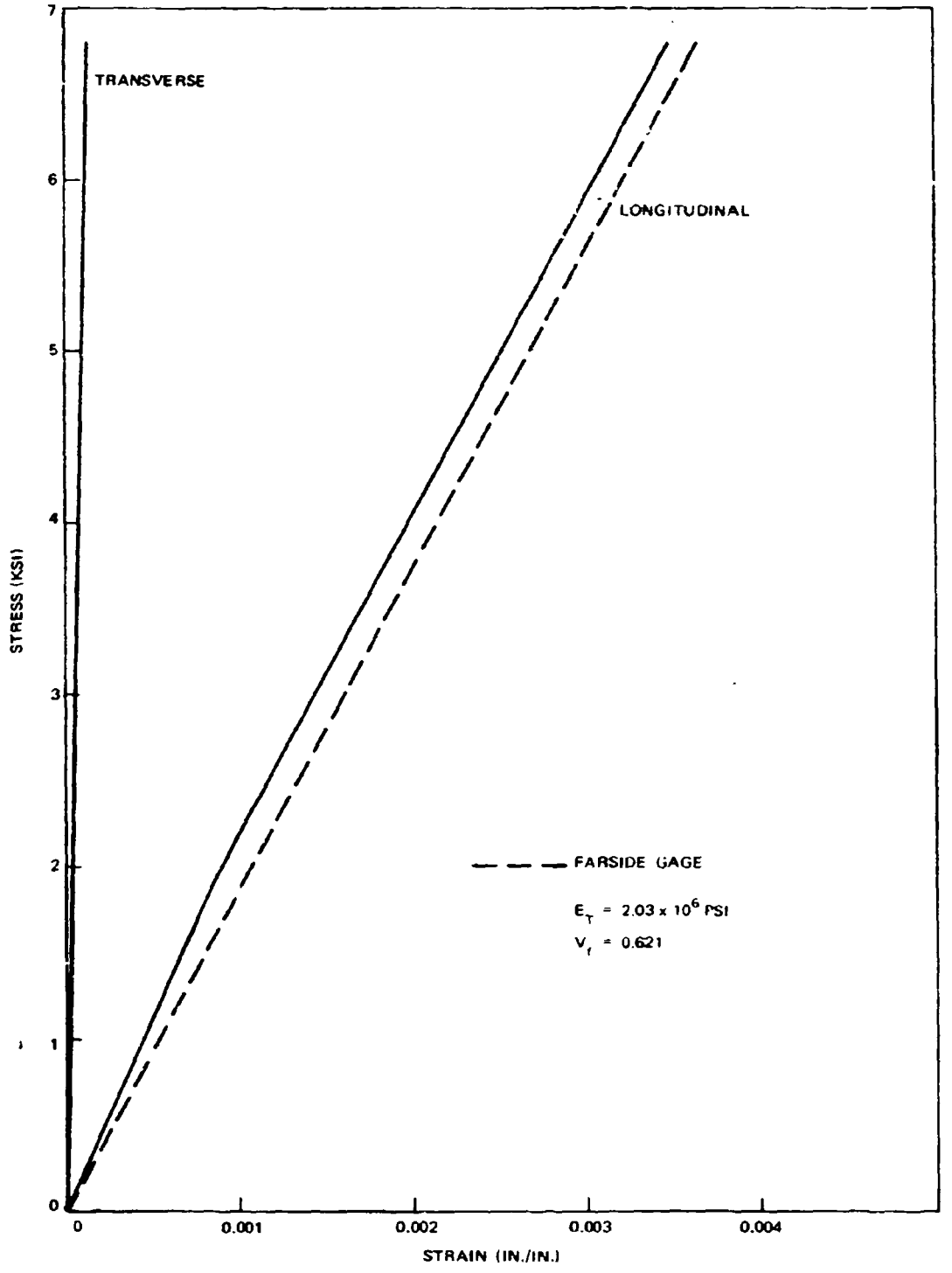


FIGURE 13. TENSILE STRESS-STRAIN DIAGRAM FOR TRANSVERSE, UNIDIRECTIONAL BORON-NARMCO 5505 LAMINATE (a)



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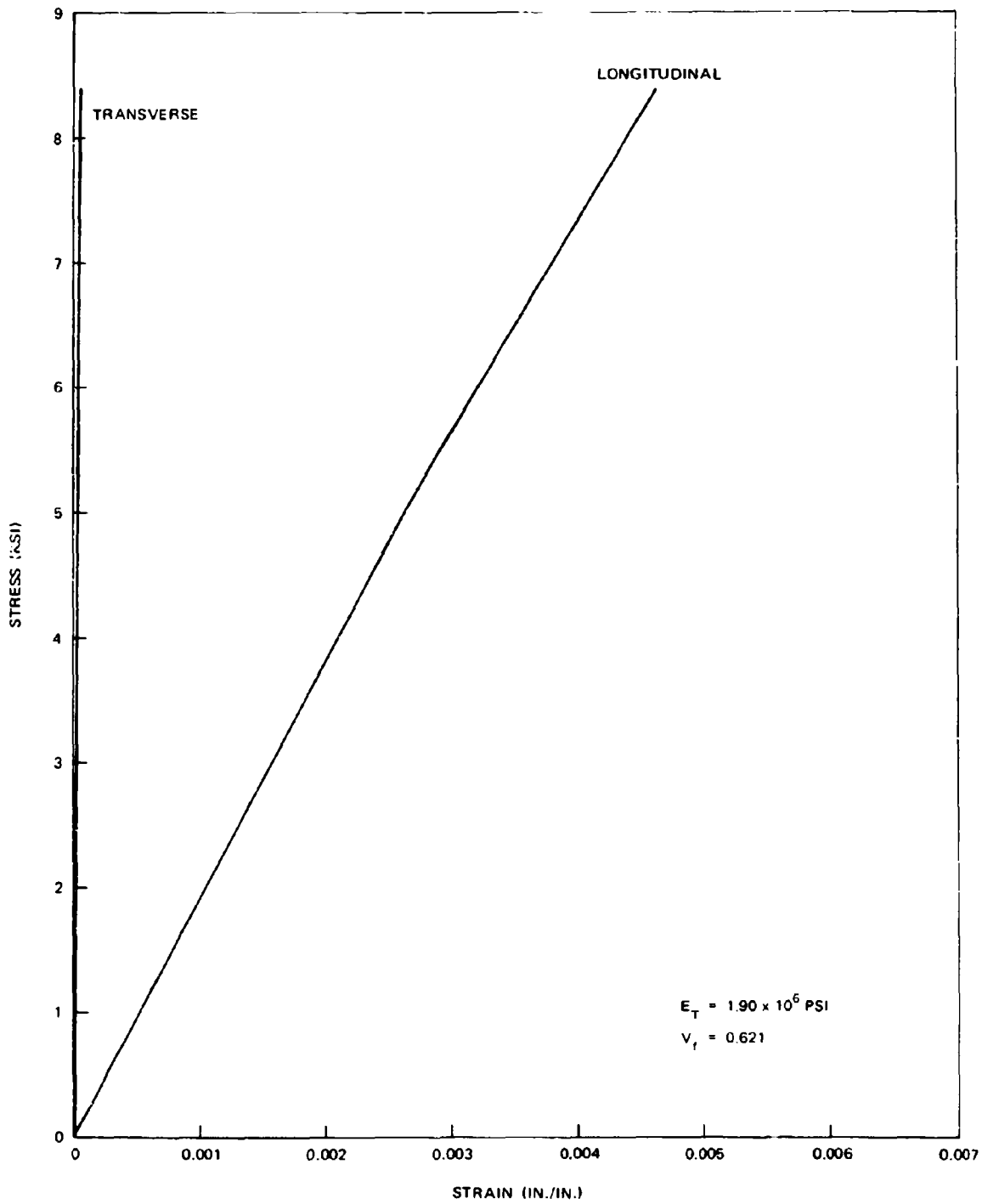


FIGURE 15. TENSILE STRESS-STRAIN DIAGRAM FOR TRANSVERSE, UNIDIRECTIONAL BORON-NARMCO 5505 LAMINATE (c)

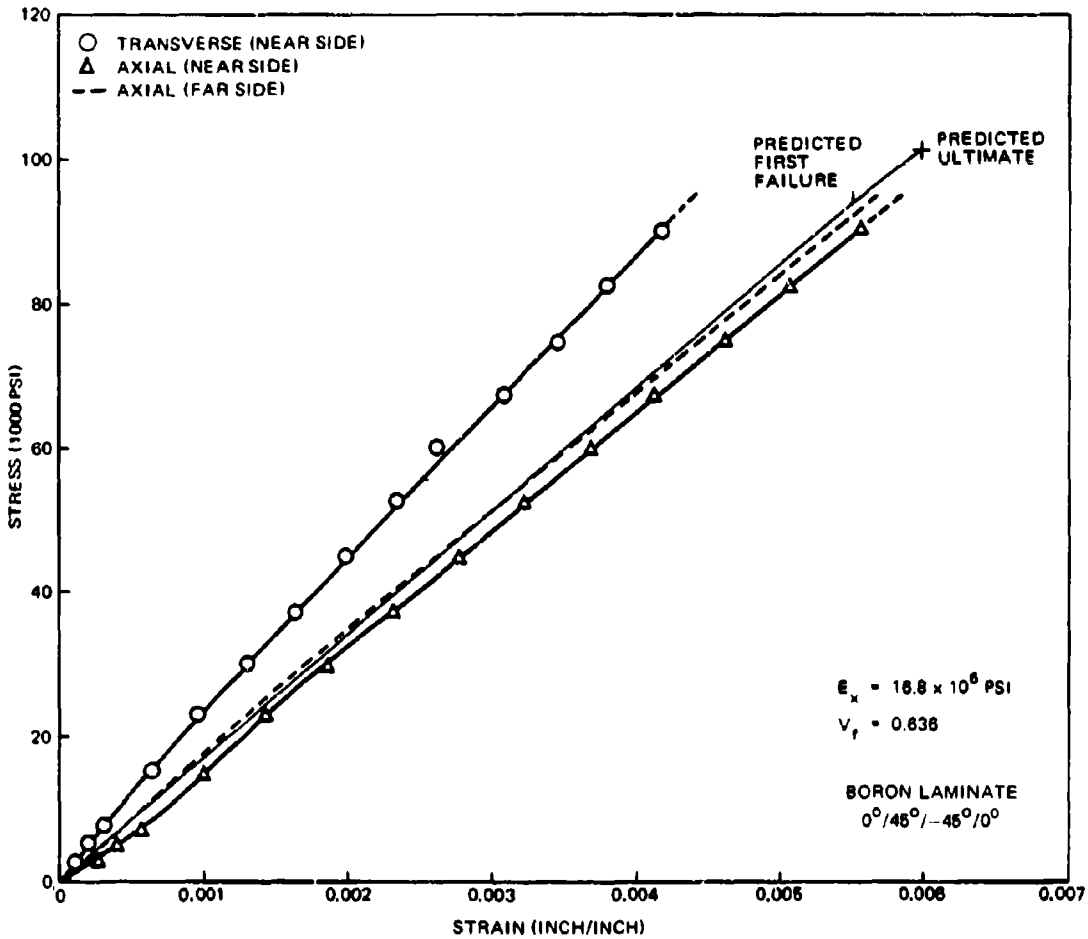
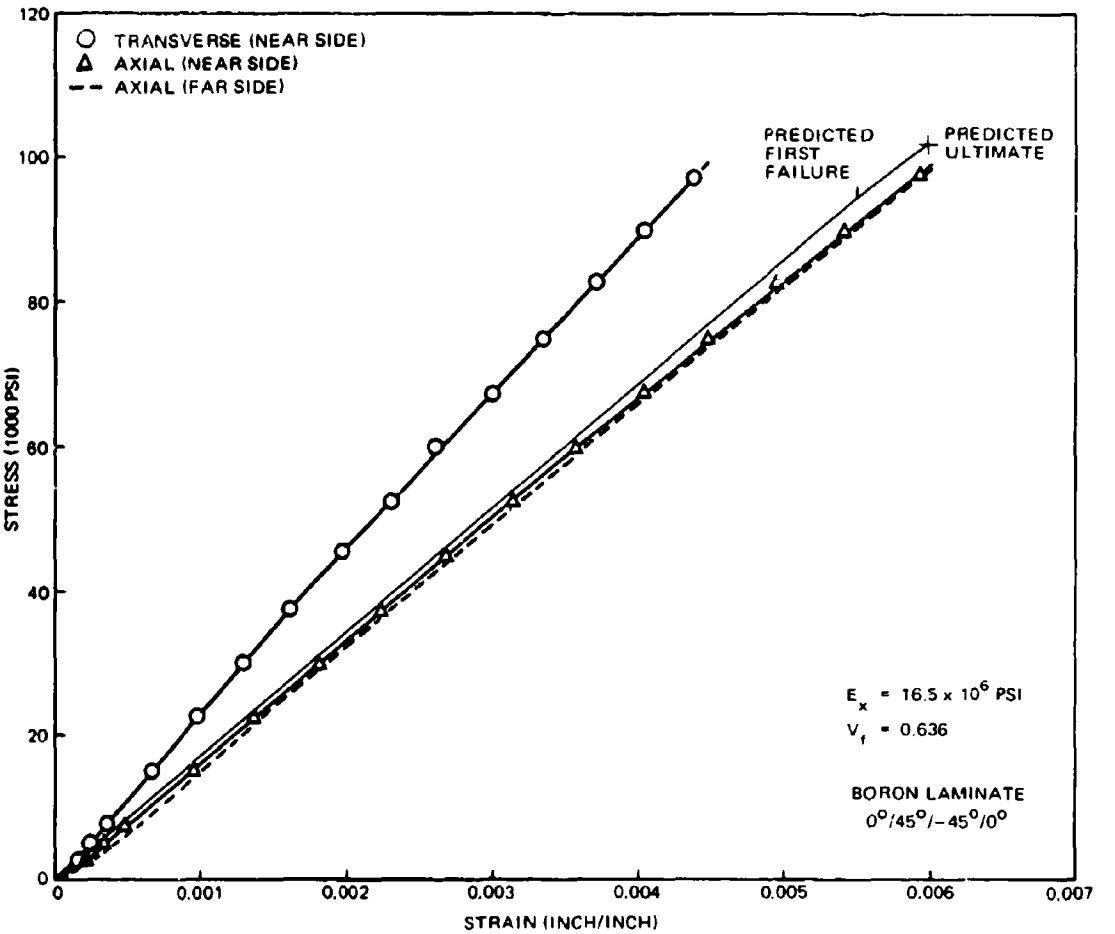


FIGURE 16. TENSILE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z4824842-1, NO. 1



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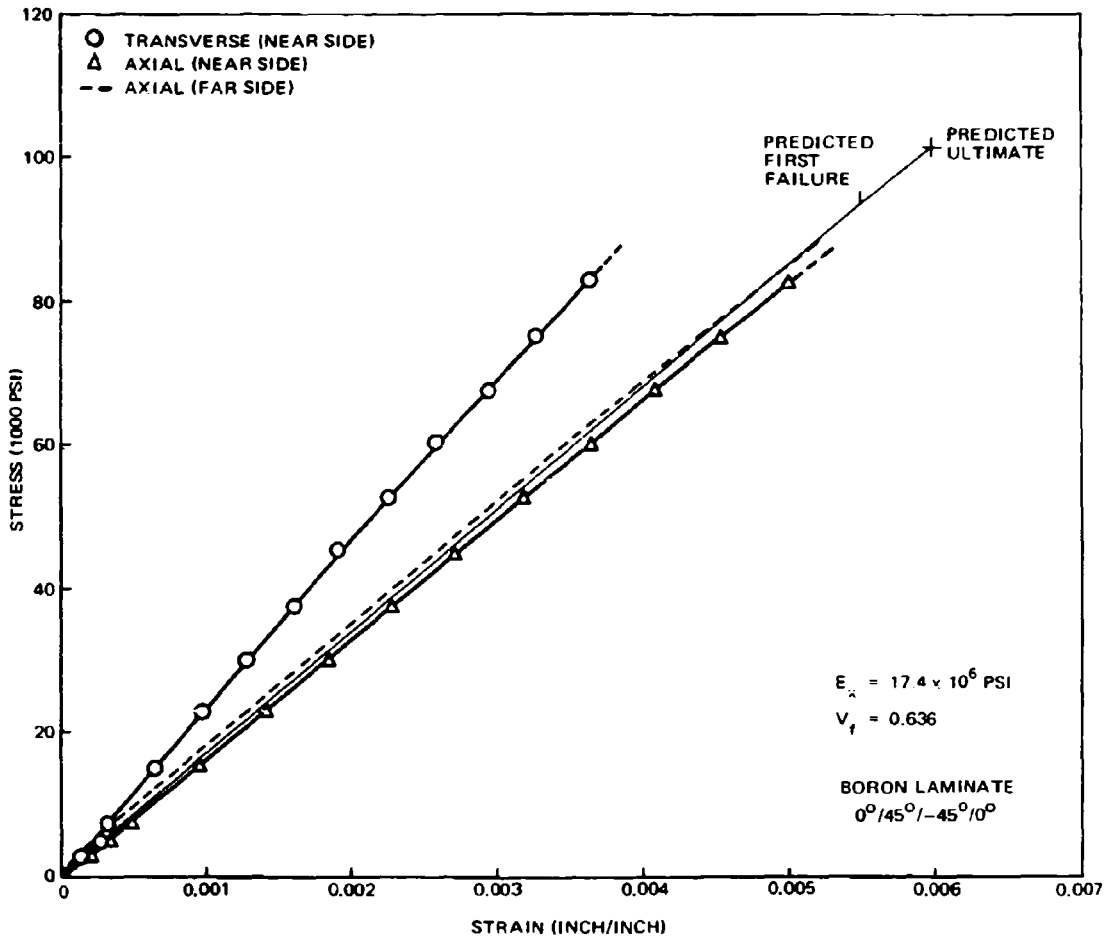


FIGURE 18. TENSILE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z4824842-1, NO. 3

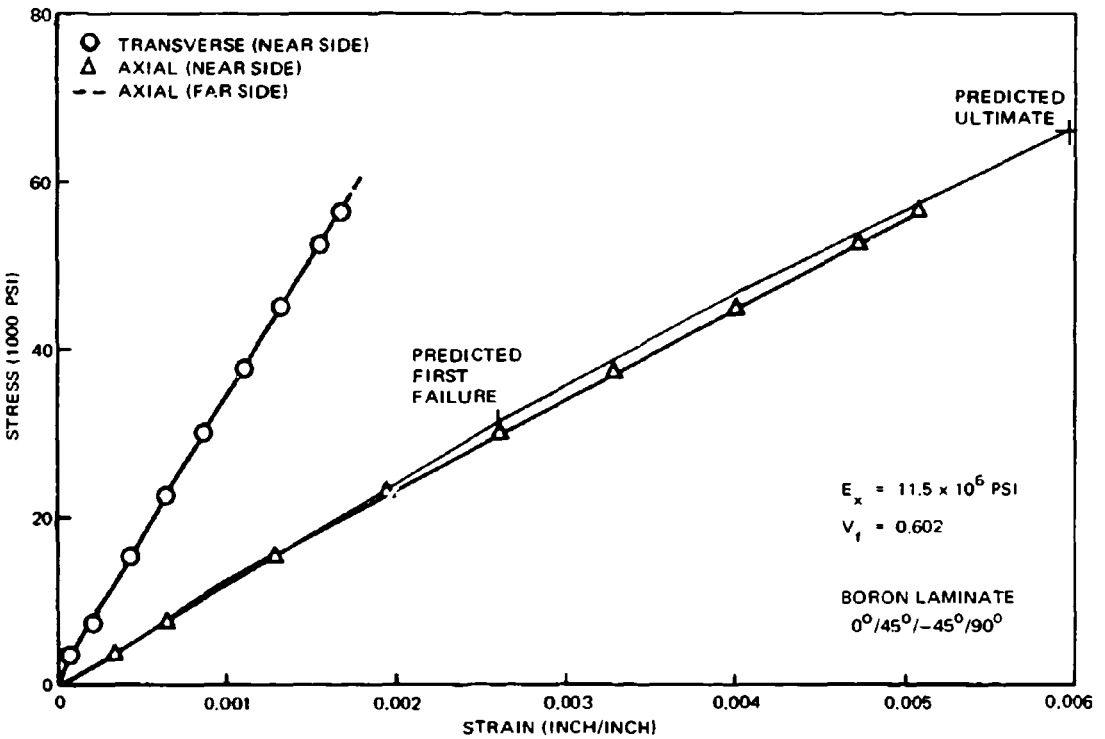


FIGURE 19. TENSILE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z4824842-501, NO. 1

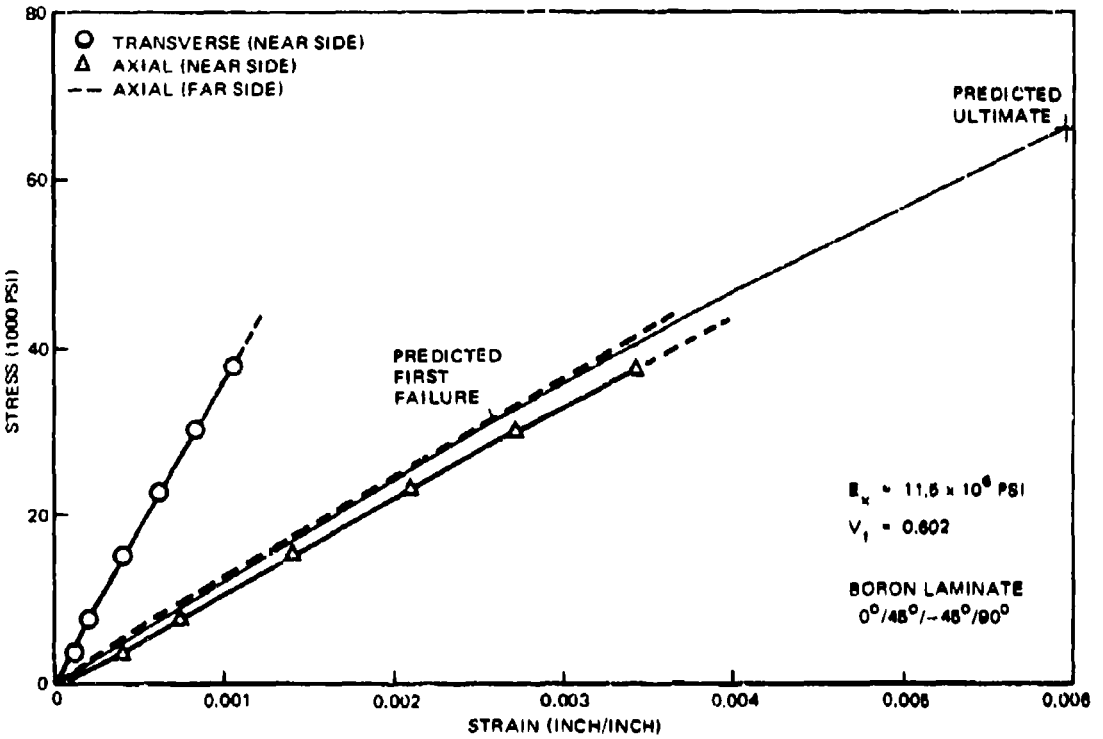


FIGURE 20. TENSILE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z4824842-501, NO. 2

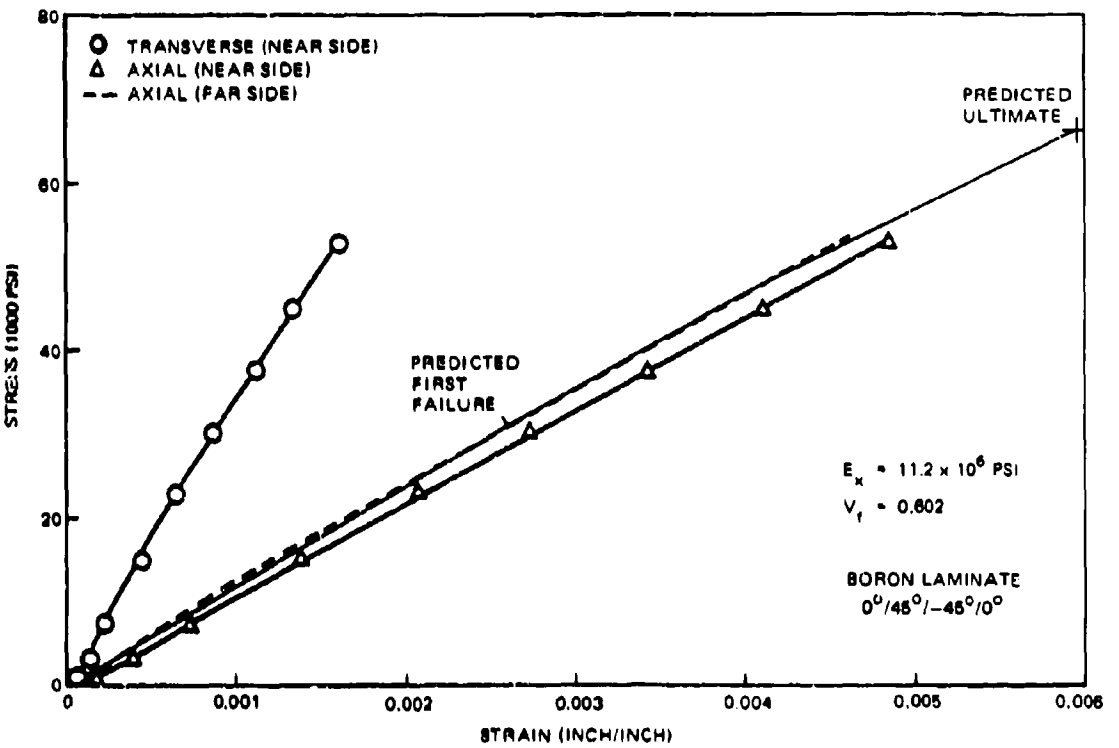


FIGURE 21. TENSILE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z4824842-501, NO. 3

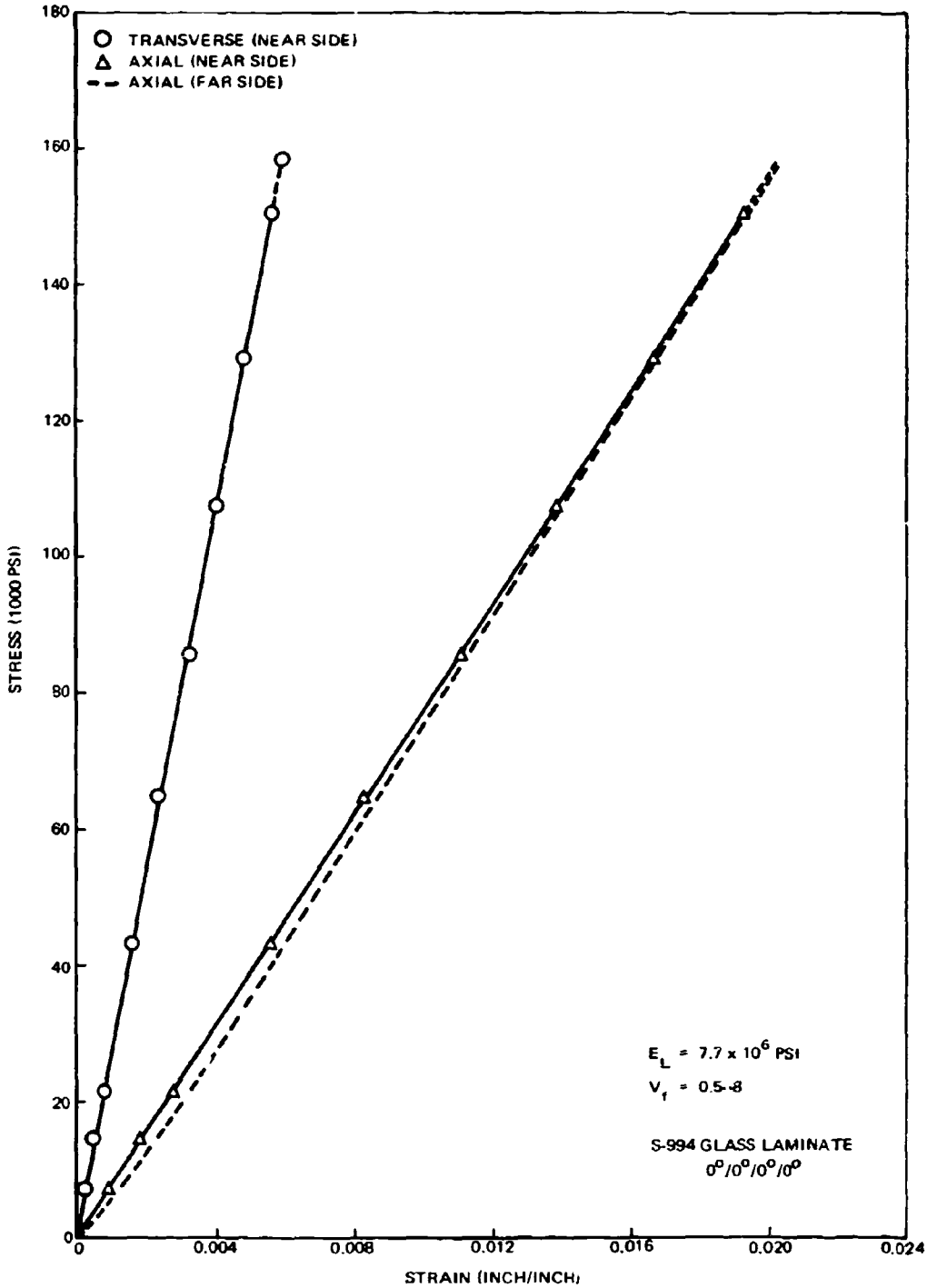
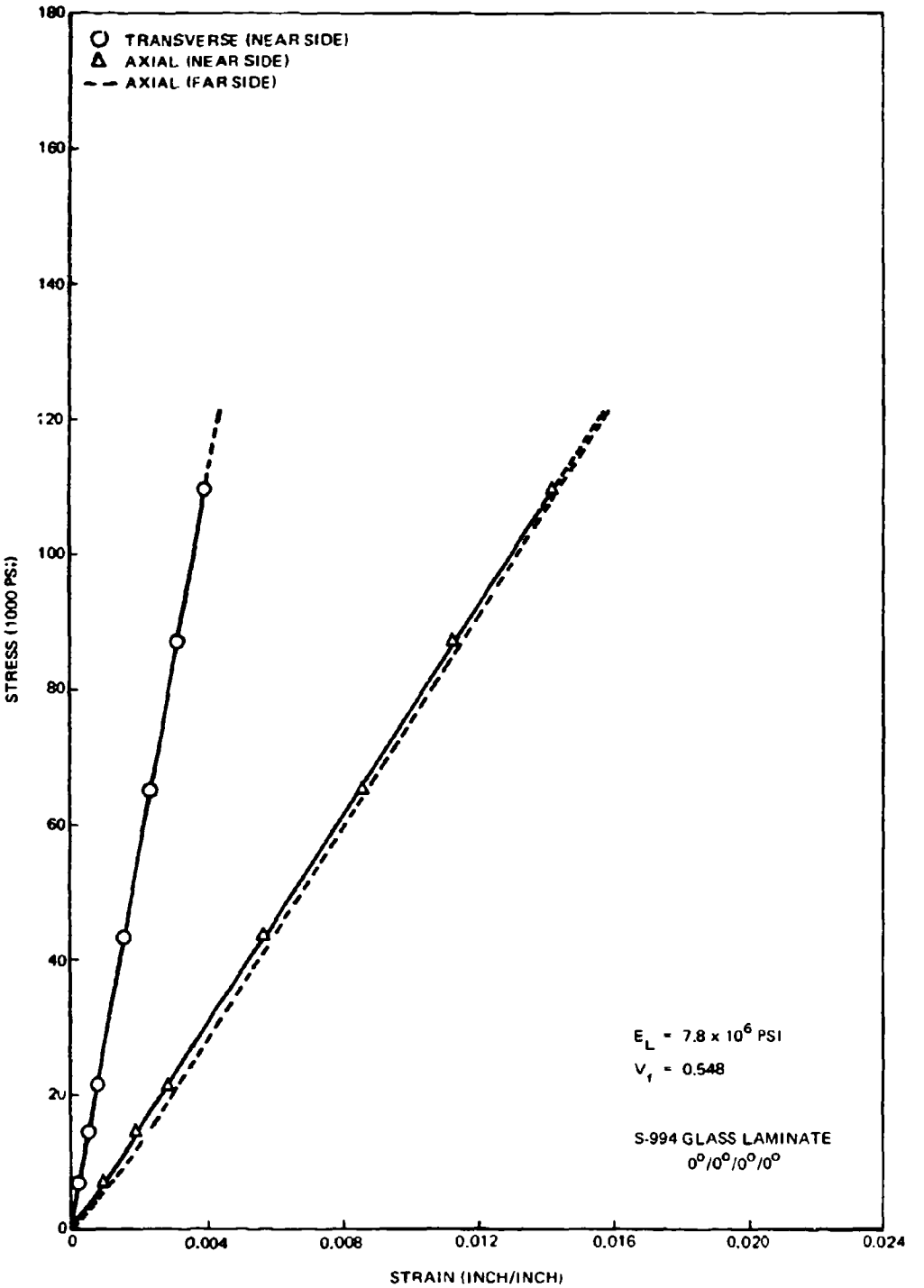


FIGURE 22. TENSILE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z4824842-503, NO. 1



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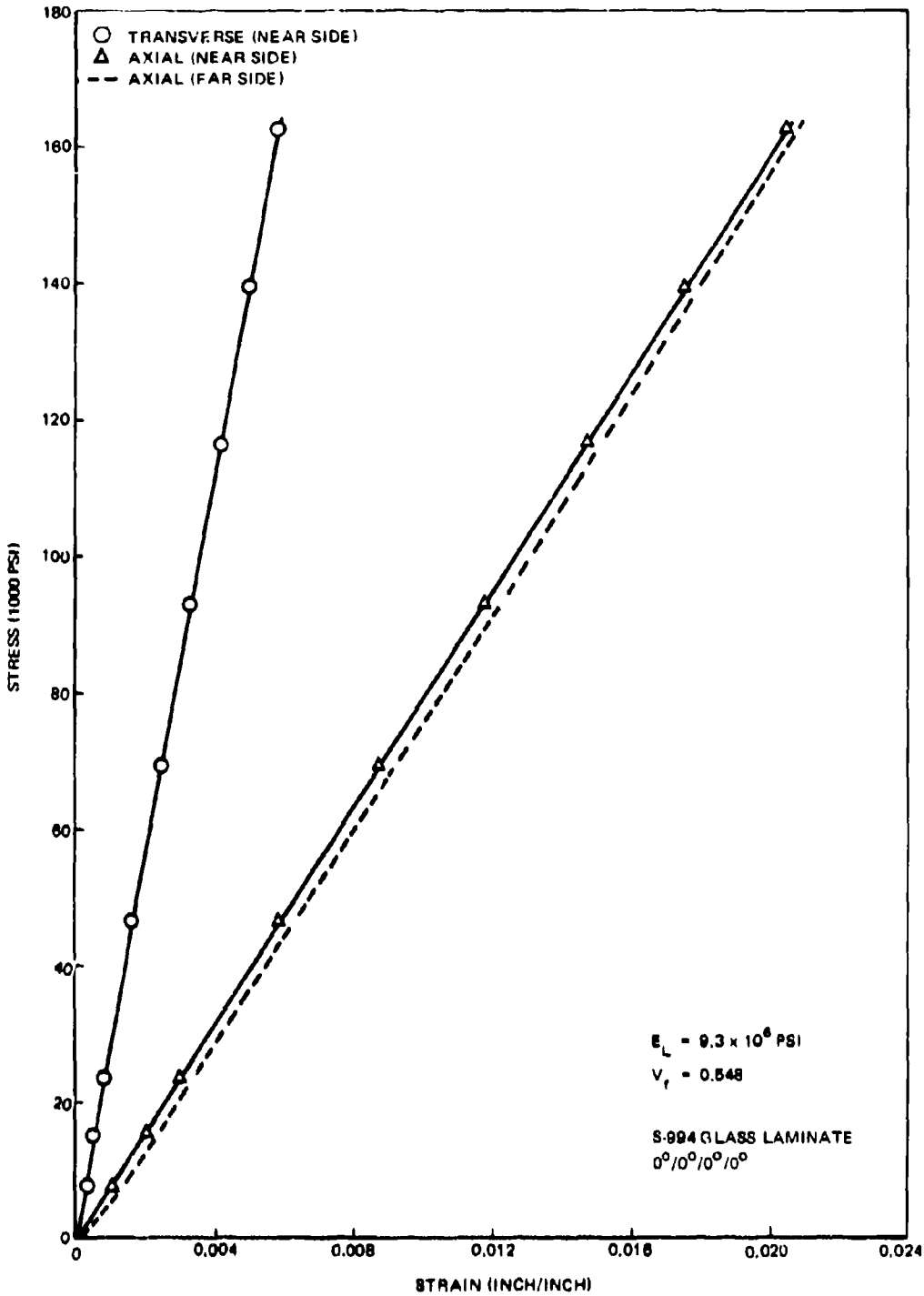
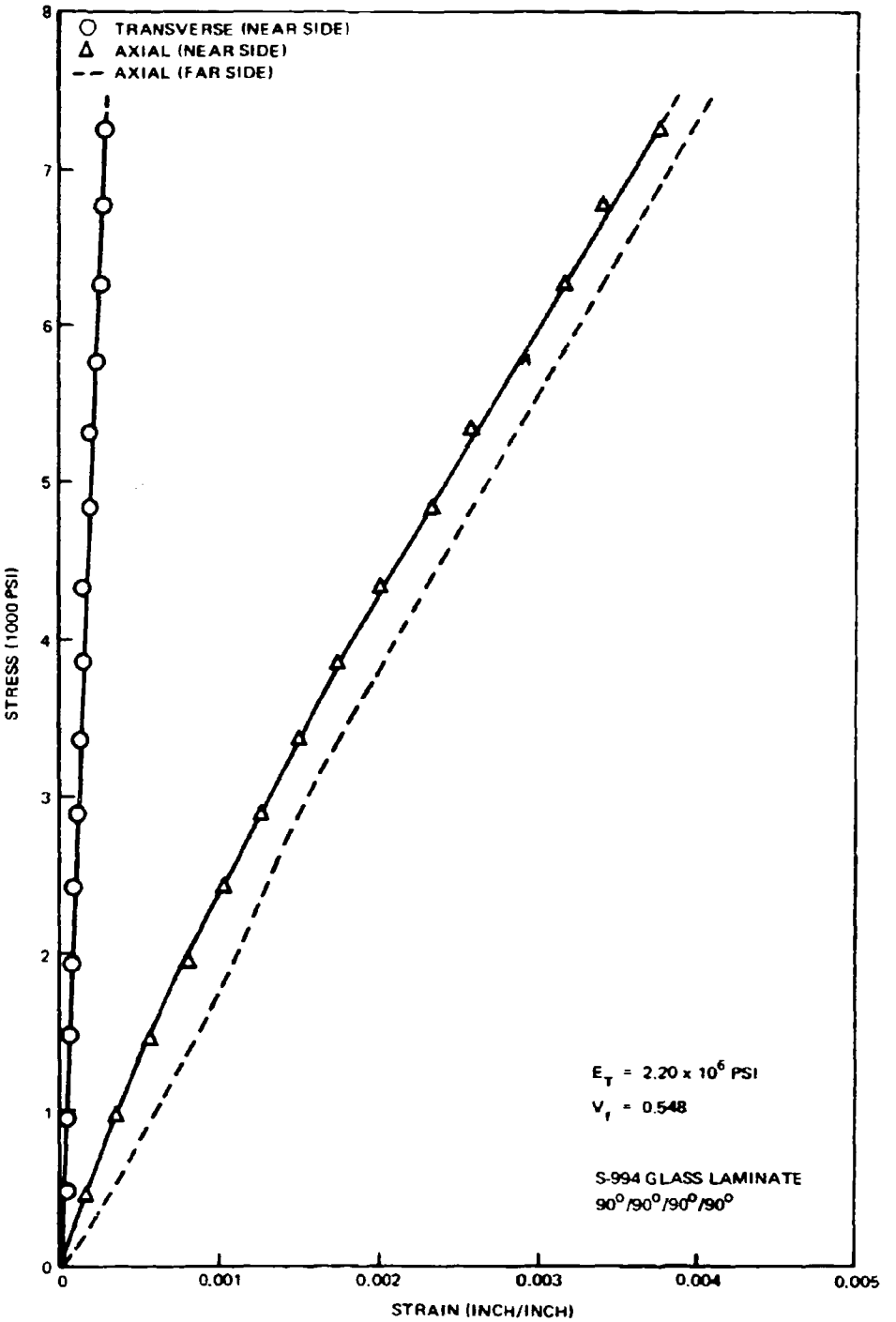


FIGURE 24. TENSIL STRESS-STRAIN DIAGRAM FOR SPECIMEN Z4824842-503, NO. 3



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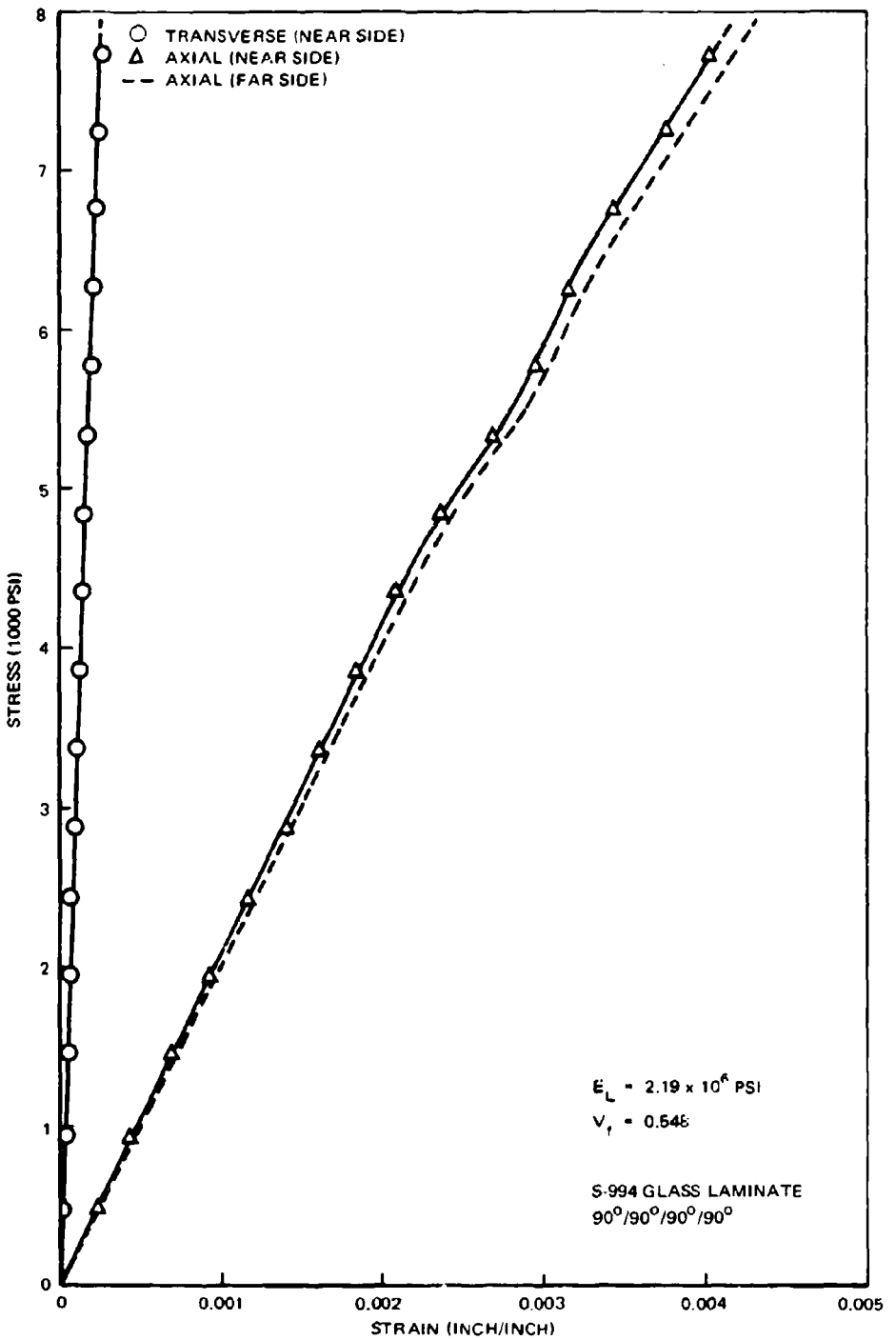


FIGURE 26. TENSILE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z4824842-505, NO. 2

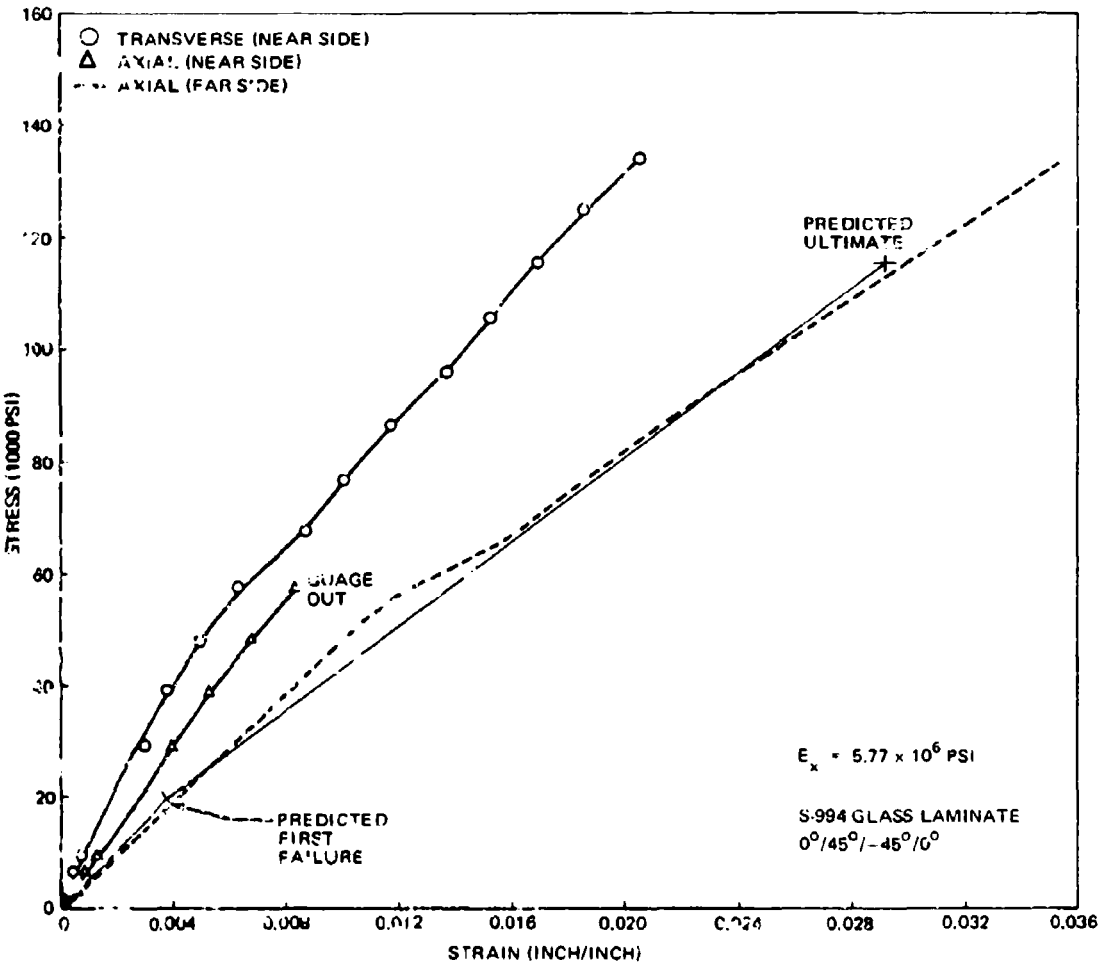


FIGURE 27. TENSILE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z4824842-507, NO. 1

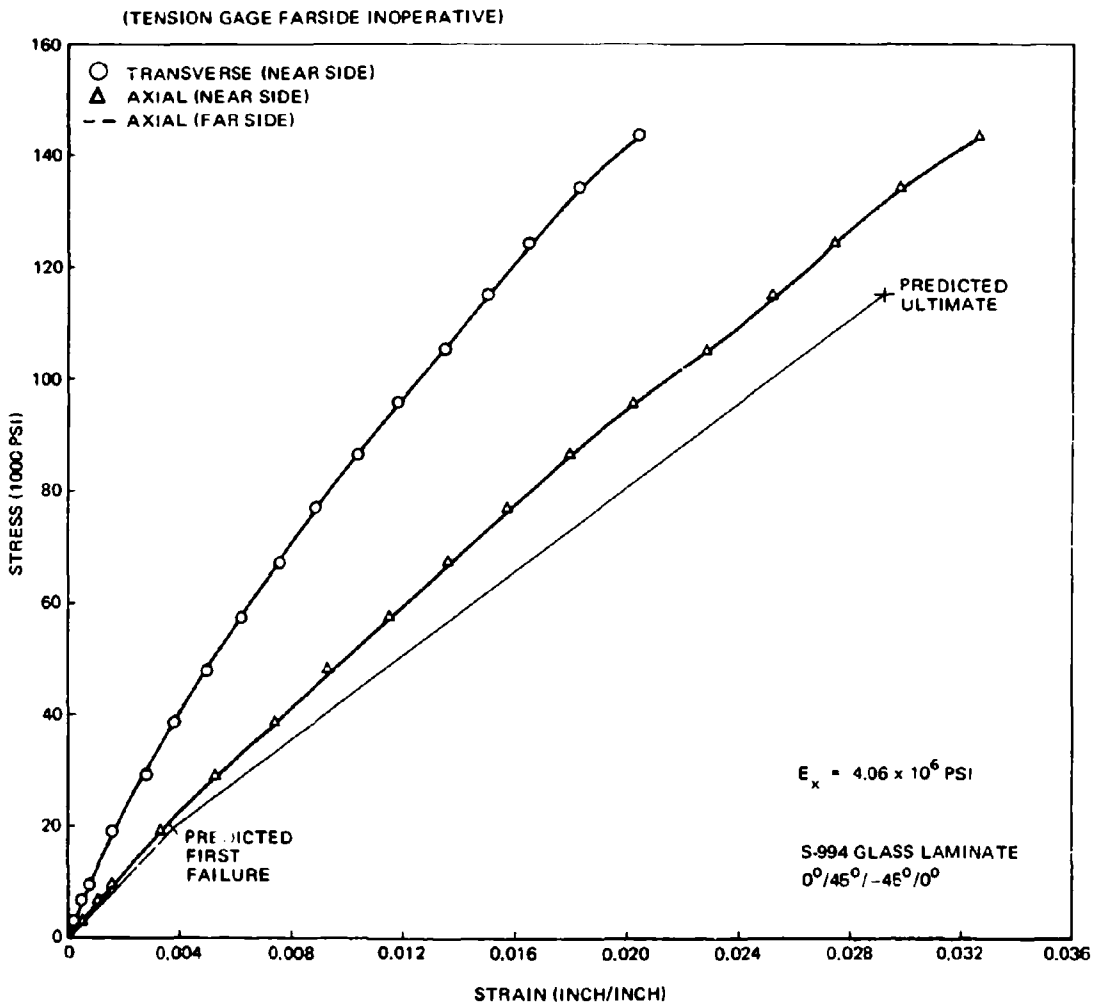


FIGURE 28. TENSILE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z4824842-507, NO. 2

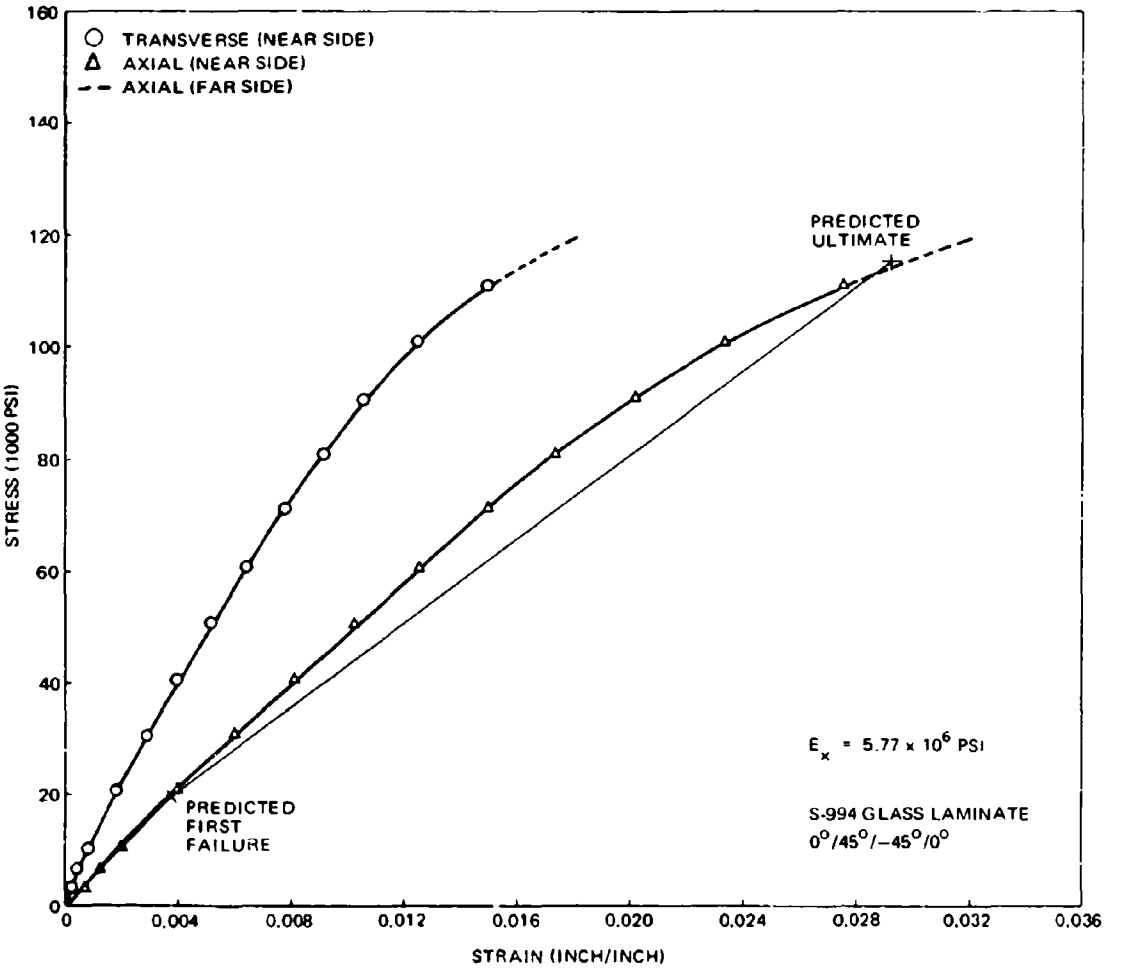


FIGURE 29. TENSILE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z4824842-507, NO. 3

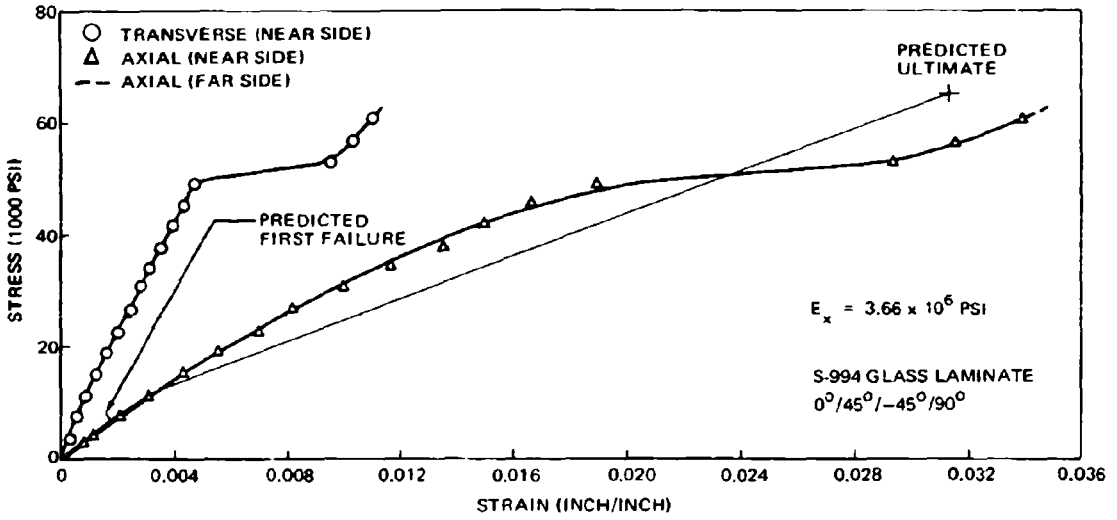


FIGURE 30. TENSILE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z4824842-509, NO. 1

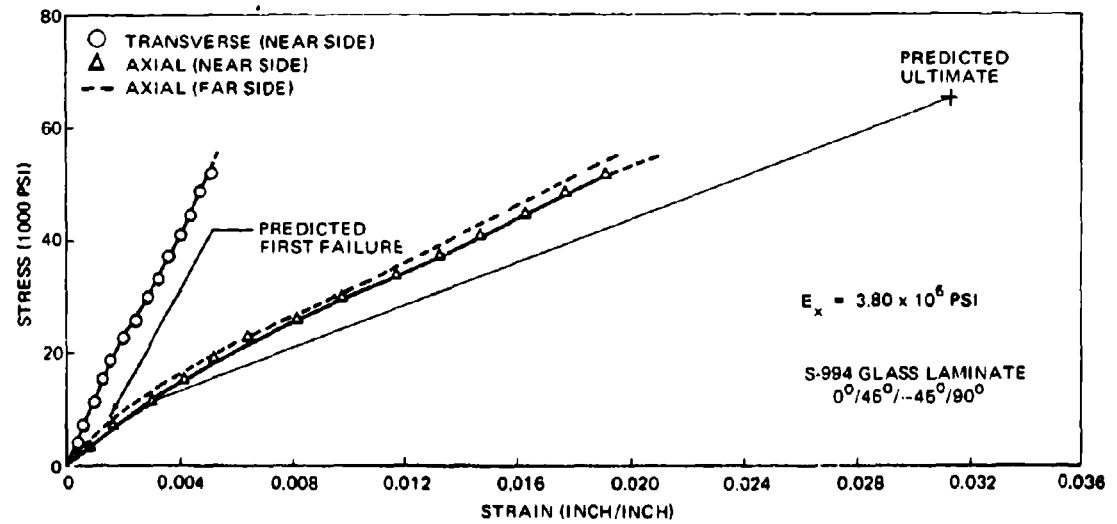


FIGURE 31. TENSILE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z4824842-509, NO. 2

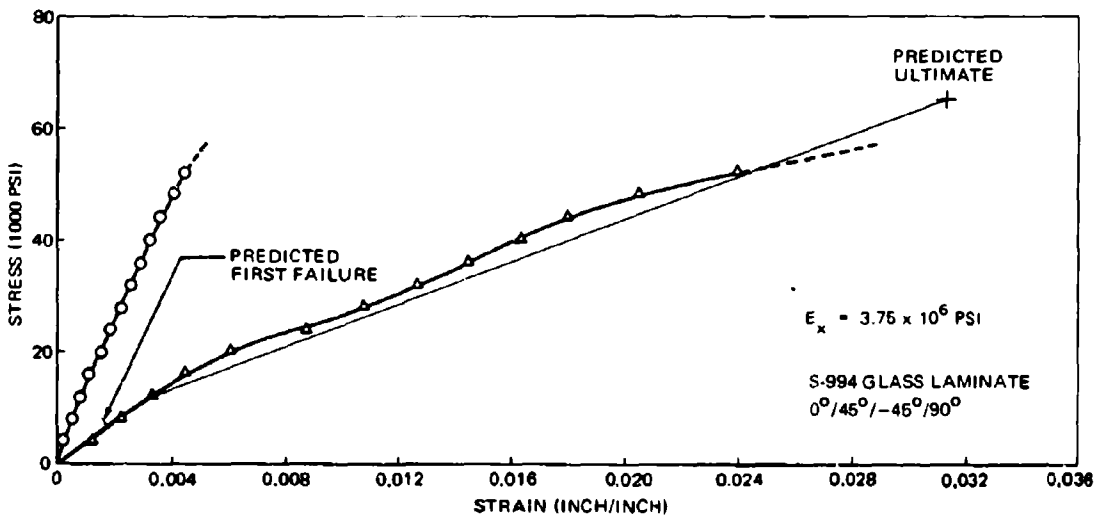
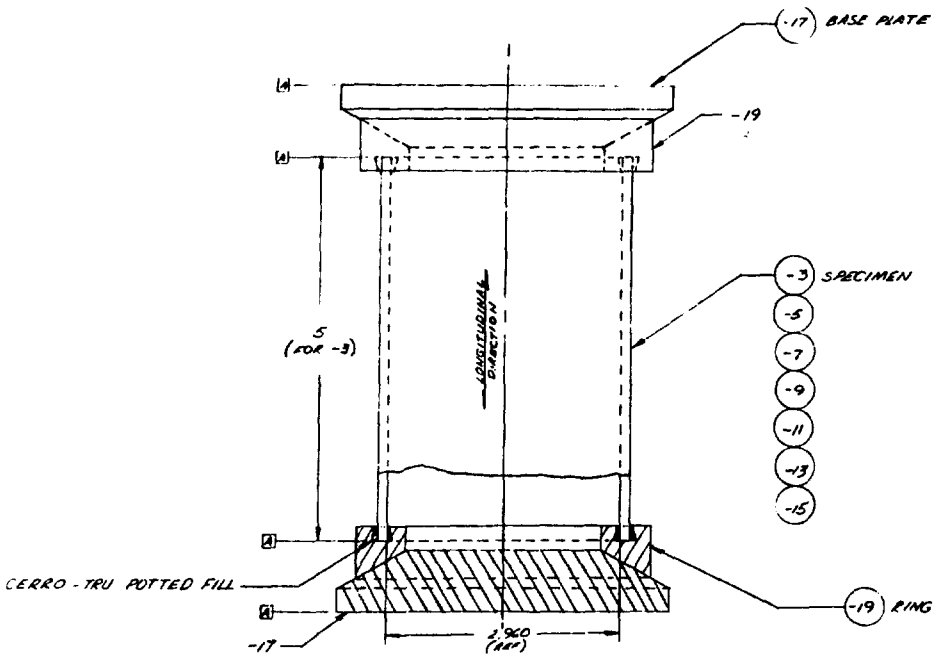
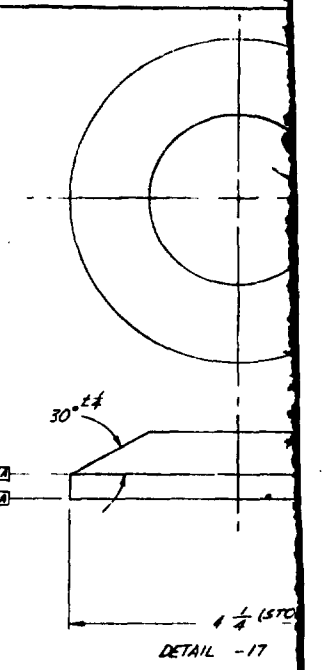
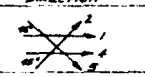
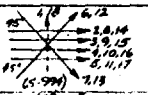
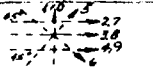


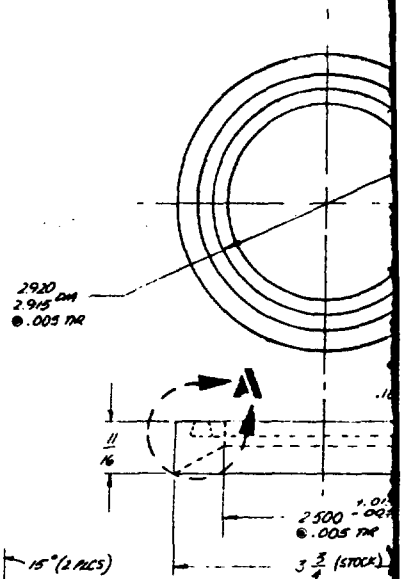
FIGURE 32. TENSILE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z4824842-509, NO. 3



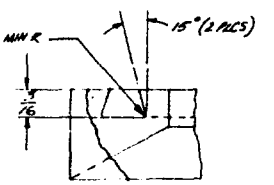


DETAIL -17

DASH NO.	FIBER MAT'L	FIBER PATTERN (LONGITUDINAL DIRECTION)	NO. OF PATTERN REPETITIONS	NOMINAL SPECIMEN THICKNESS
-3	BORON FMS200VA		6	.120
-5	S-994 NTS GLASS	SAME AS -1	3	.120
-7	BORON * NOTED		NOTED	100 20% CIRCS 20% ± 45° 60% LONGS
-9	S-994 NTS GLASS		NOTED	.100 20% CIRCS 20% ± 45° 60% LONGS
-11	BORON	IDENTICAL TO -1 EXCEPT FOR ADDITION OF SILICON CARBIDE WHISKERS AT APPROXIMATELY 2% OF RESIN WEIGHT		.120
-13	BORON	IDENTICAL TO -1 EXCEPT FOR ADDITION OF SILICON CARBIDE WHISKERS AT APPROXIMATELY 1% OF RESIN WEIGHT		.120
-15	BORON	IDENTICAL TO -11 EXCEPT USING ALUMINUM OXIDE/ALUMINUM NITRIDE WHISKER MIXTURE		.120



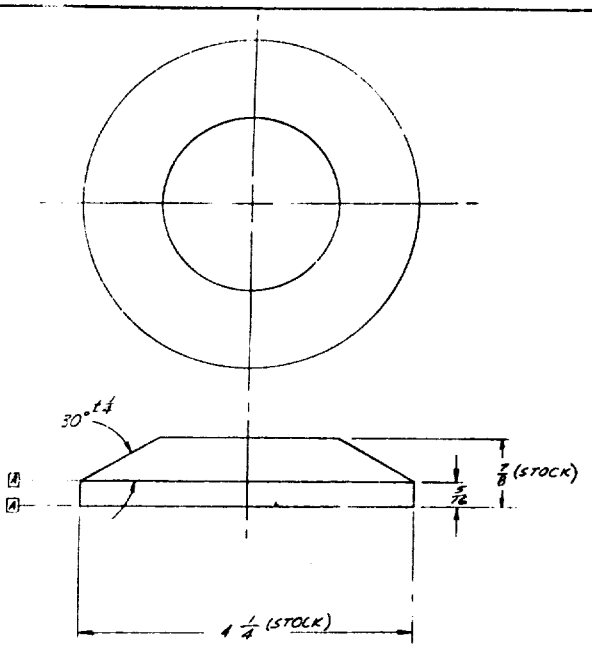
DETAIL -19



VIEW A SCALE 2/1

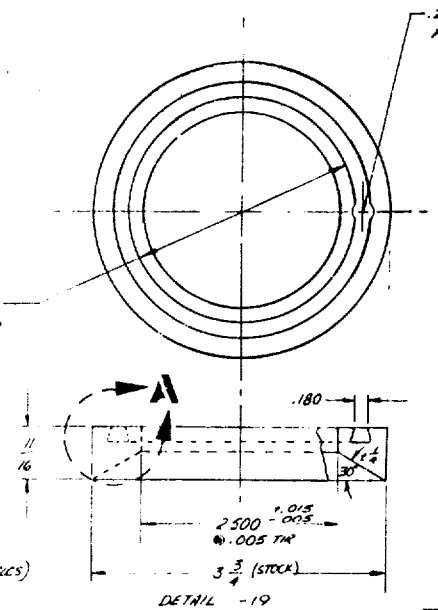
A

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



DETAIL -17

GEN NOTES: UNLESS OTHERWISE NOTED
1. SPECIMEN FAB & PROCESSING METHODS PER DPS 1.463-3824818
2. IDENTIFY PER DPS 3.02
3. USE TABLE BELOW FOR SPECIMEN INFO
4. -17 TO BE PURCHASED HOT ROLLED & ANNEALED
5. PARTS MARKED THUS ⒜ TO BE FLAT & PARALLEL WITHIN .002 TIR
6. FAB PRACTICES FOR -17 & -19 PER DPS 4.710
7. BREAK ALL SHARP CORNERS .032 R
8. HARD ANODIZE - 19 PER DPS 11.04
9. ALL MACHINED SURFACES ON -17 & -19 TO BE ▽ PER MIL-STD-10
10. FIRST ISSUE RELEASE REQ'MNTS:
    3 EA REQ'D OF -3 THRU -15 INCL
    2 EA REQ'D OF -17
    42 EA REQ'D OF -19
11. HEAT TREAT -17 TO 125-145,000 PSI PER DPS 5.000



DETAIL -19

2	2	2	2	2	2	2	-19	RING		3 ¾ DIA x ¾	AL BAR 7075-T651	QQ-A-225/9 TEMP T651	
2	2	2	2	2	2	2	-17	BASE PLATE		4 ½ DIA x ⅞	STL BAR 4130	MIL-S-6758 SEE NOTE 4	
1							-15	SPECIMEN			BORON &	SILICON CARBIDE WHISKERS	
	1						-13	↓	↓	↓	BORON &	SAPPHIRE WHISKERS	
		1					-11				BORON &	SAPPHIRE WHISKERS	
			1				.9				S-994 NTS GLASS		
				1			-7				BORON &	S-994 GLASS	
					1		-5				S-994 NTS GLASS		
						1	-3	SPECIMEN			BORON	FMS 200M	
-511	-509	-507	-505	-503	-501	-1	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	STOCK SIZE	MATERIAL DESCRIPTION	MATERIAL SPECIFICATION	FIND NO.

LIST OF MATERIALS

DASH NUMBERS OF THIS DRAWING ODD DASH NUMBERS SHOWN EVEN DASH NUMBERS OPPOSITE

QUANTITY REQUIRED PER NOTED ASSY

FINISH

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES.
TOLERANCES
FRACTIONS ± 1/32
DECIMALS ± .015
ANGLES ± ½°

MATL		
WT CHK		
STR CHK		
CHECK		
PR ENGR	G. LEHMAN	6-7-67
DES ENGR		
GR ENGR		
PREP BY	LYDRAN	6-6-67

DOUGLAS AIRCRAFT COMPANY, INC LONG BEACH, CALIFORNIA

TEST ASSY - FIBROUS COMPOSITE COMPRESSION SPECIMEN

SEE ENGINEERING RECORDS FOR USAGE DATA

FIRST RELEASE OF PRINTS
ORIGINAL DATE OF DRAWING JUN 6 1967

DESIGN ACTIVITY APPROVAL

CUSTOMER APPROVAL

CODE IDENT NO 88277 | SIZE D | Z3824818

SCALE 1/1 | SHEET 1 OF 1

SCALE 2/1

DRAWING Z3824818. TEST ASSEMBLY — FIBROUS COMPOSITE COMPRESSION SPECIMEN

B

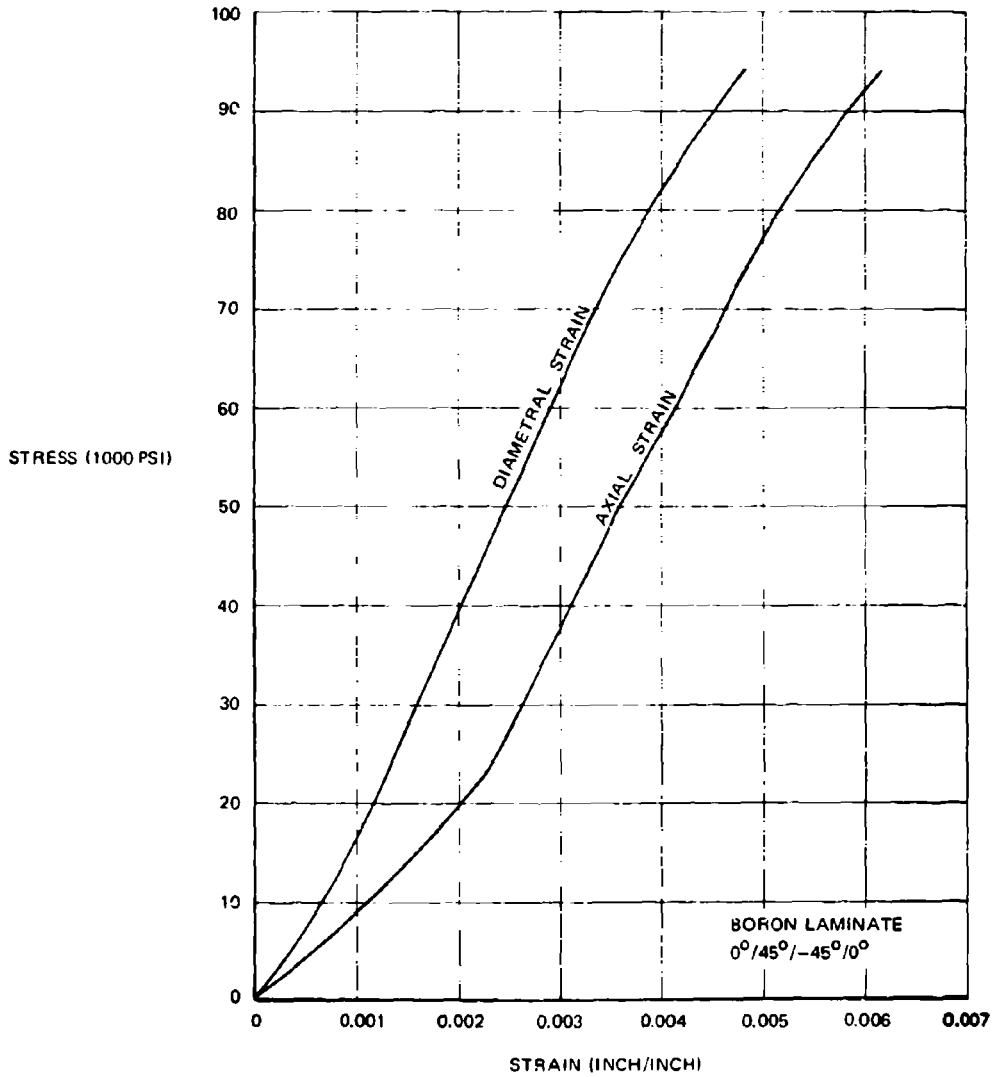


FIGURE 33. COMPRESSIVE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z38248418-1, NO. 1

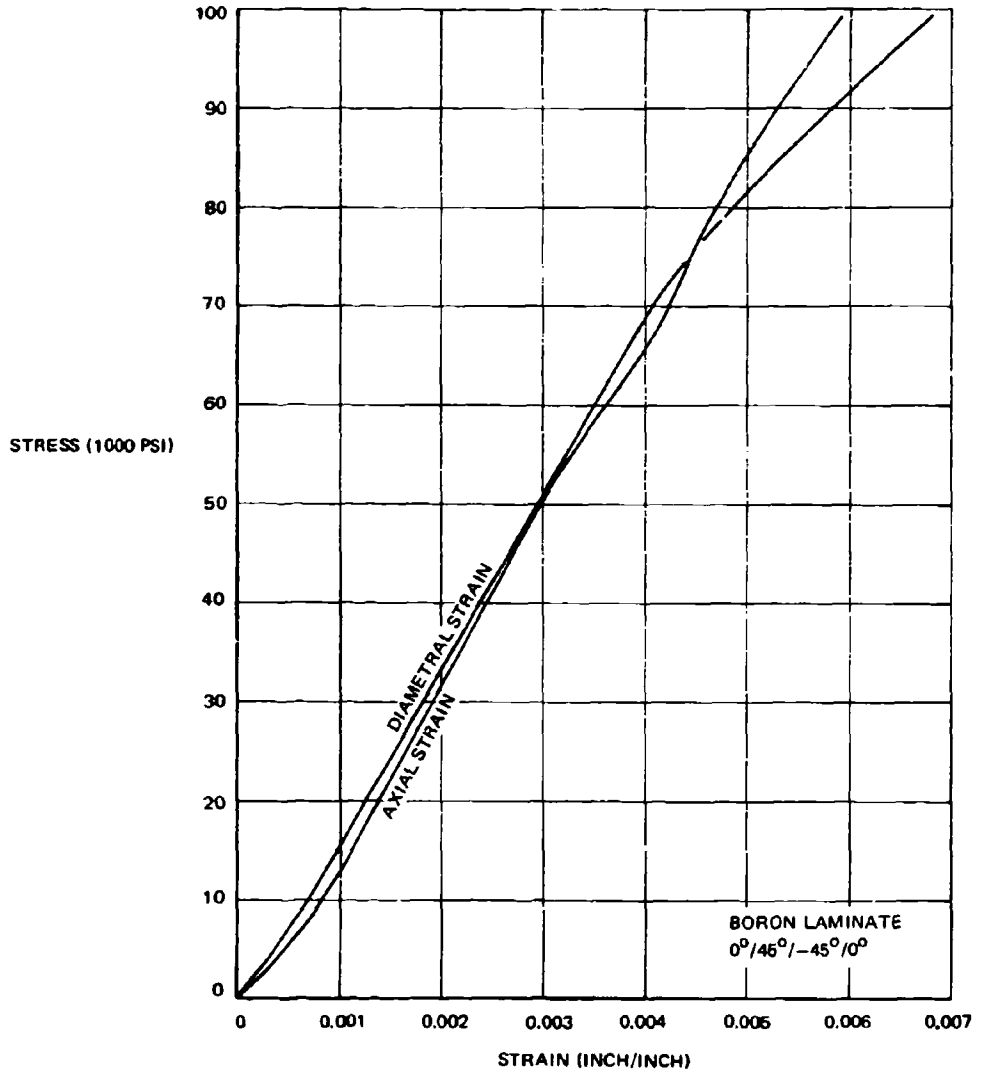


FIGURE 34. COMPRESSIVE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824818-1, NO. 2 (FIRST LOAD APPLICATION)

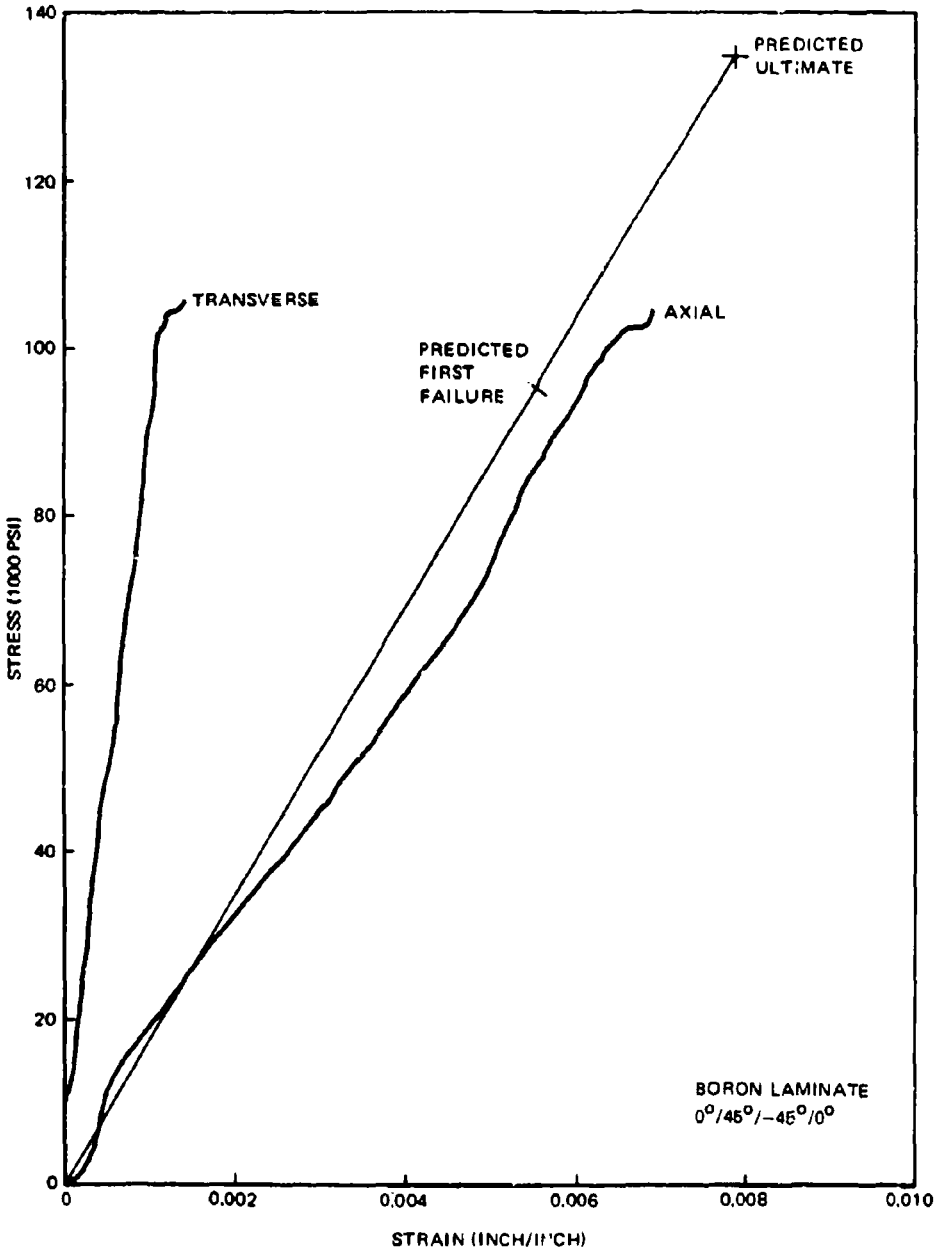


FIGURE 35. COMPRESSIVE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824818-1, NO. 2 (SECOND LOAD APPLICATION)

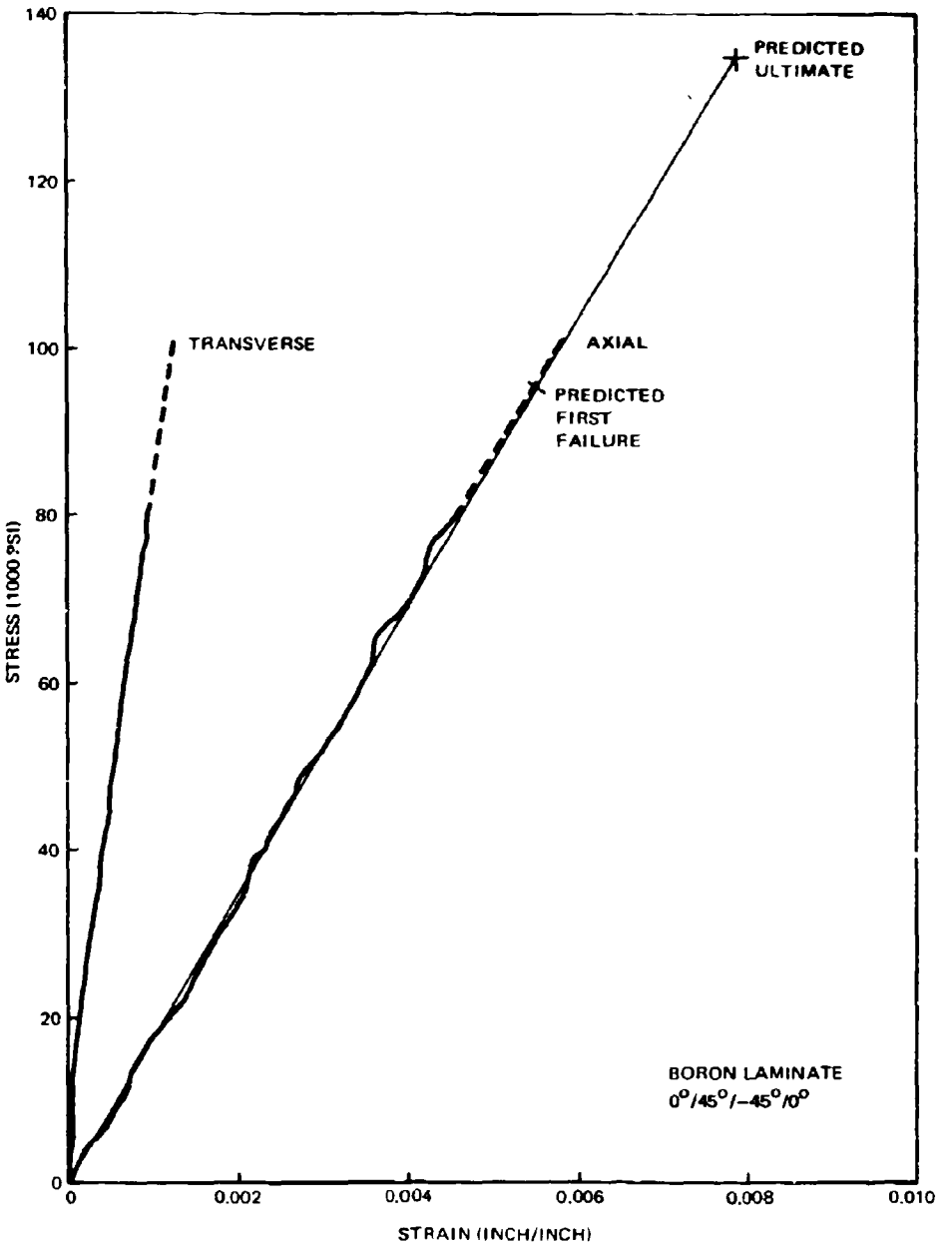


FIGURE 36. COMPRESSIVE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824818-1, NO. 3

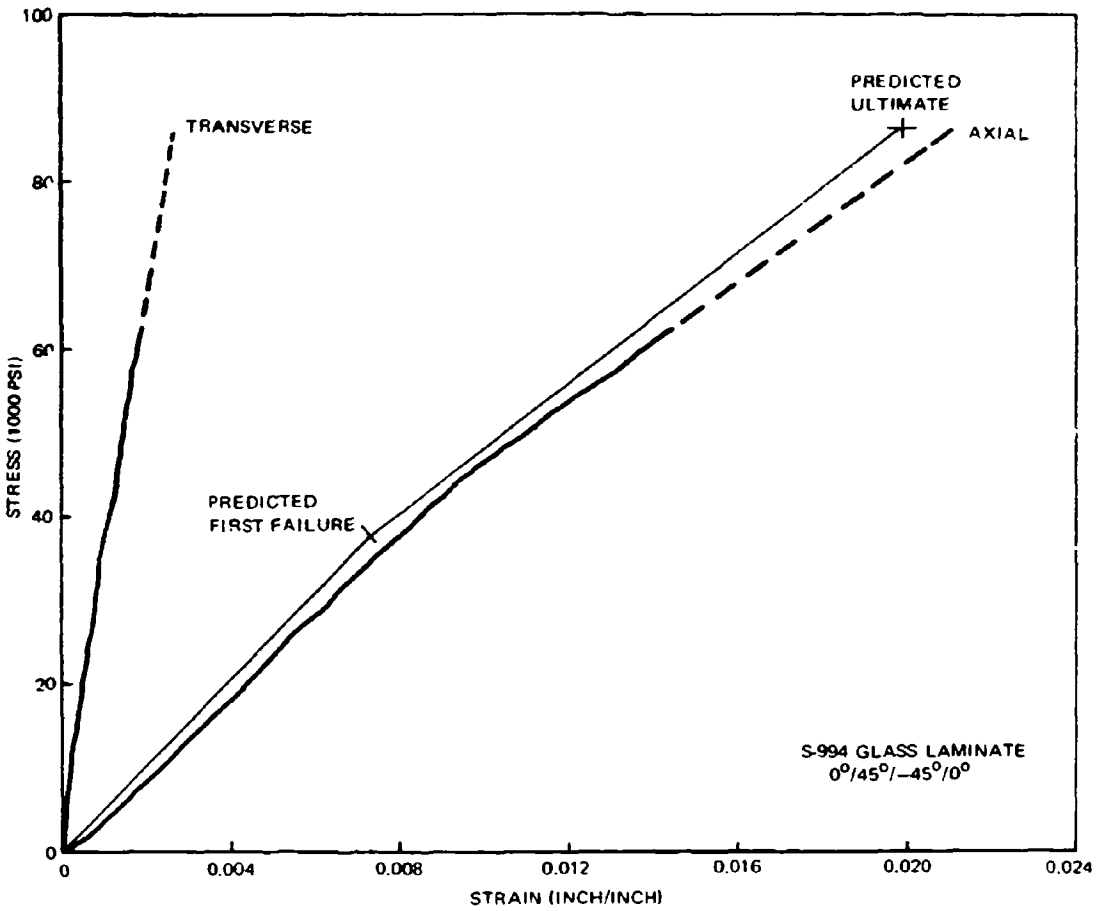


FIGURE 37. COMPRESSIVE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824818-501, NO. 1

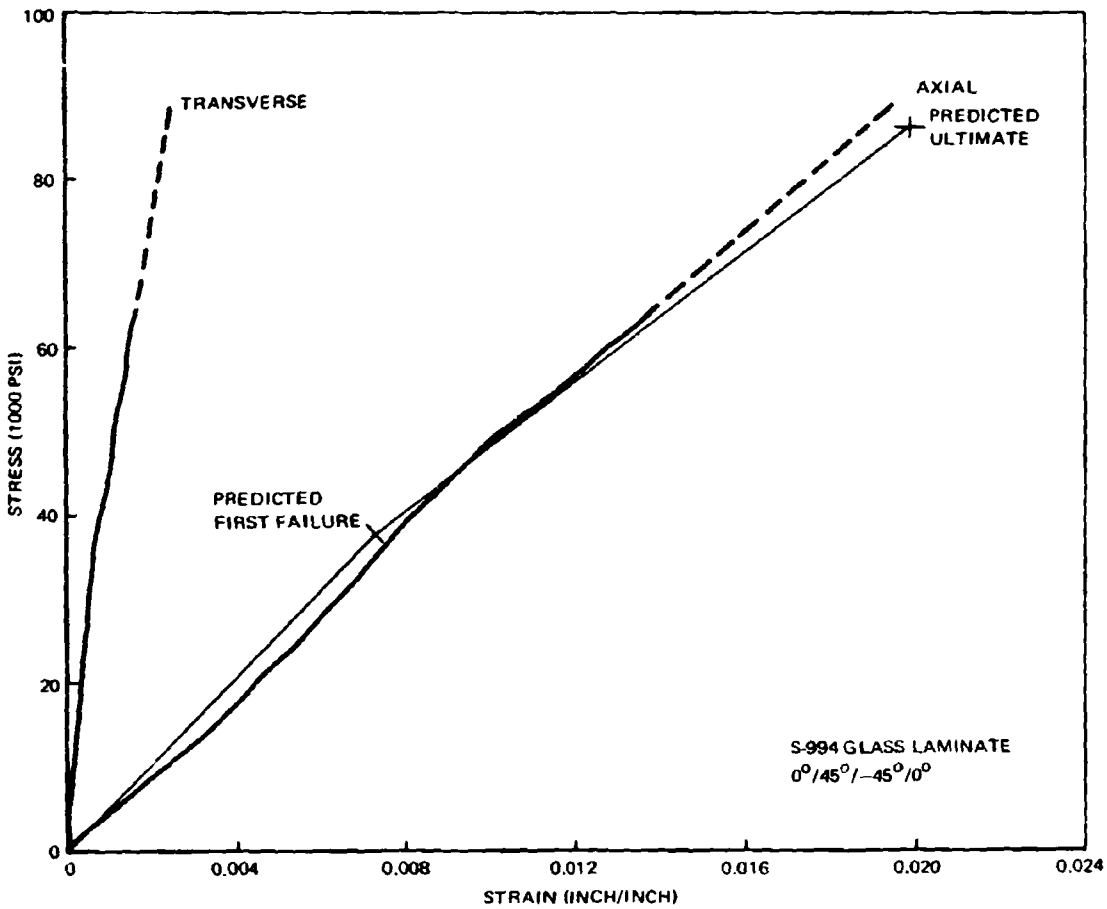


FIGURE 38. COMPRESSIVE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824818-501, NO. 2

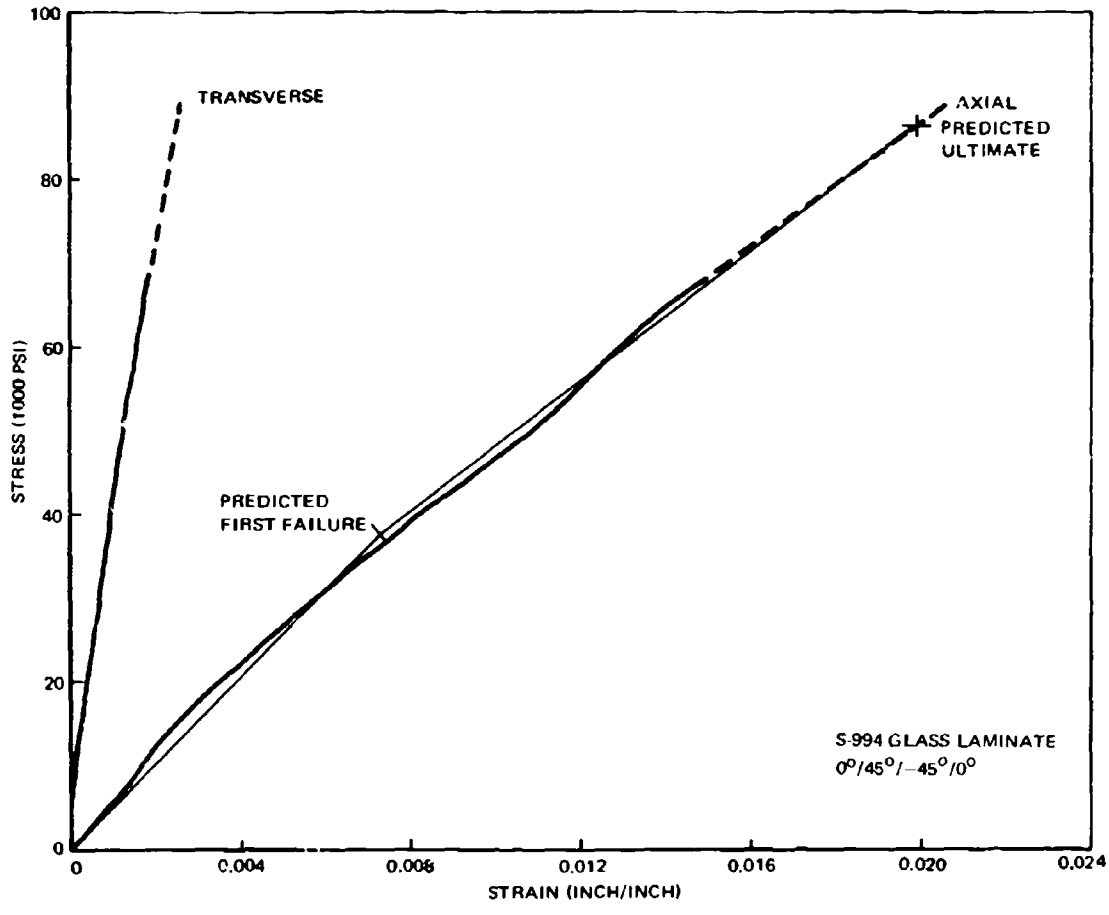


FIGURE 39. COMPRESSIVE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824818-501, NO. 3

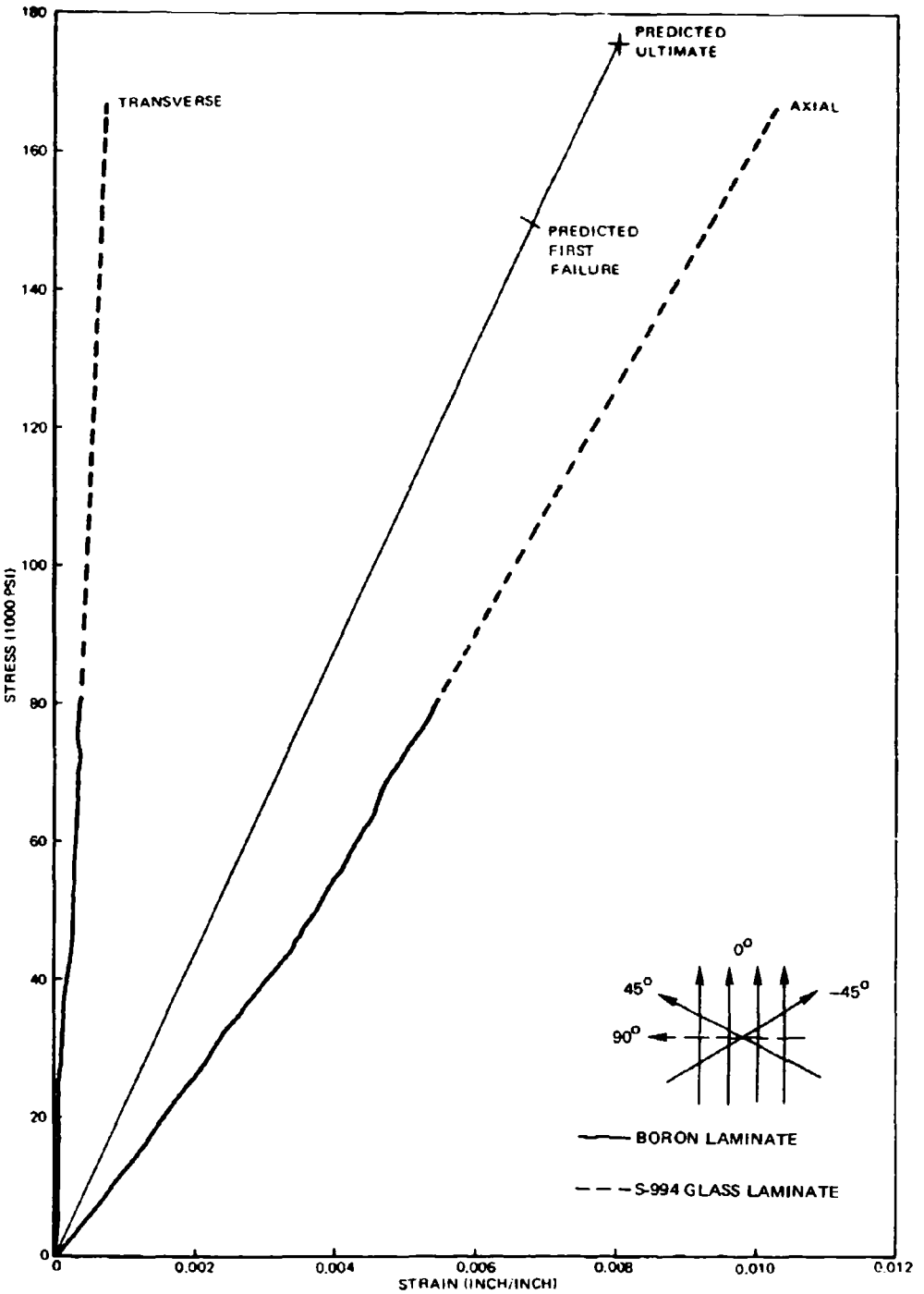


FIGURE 40. COMPRESSIVE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824818-503, NO. 1

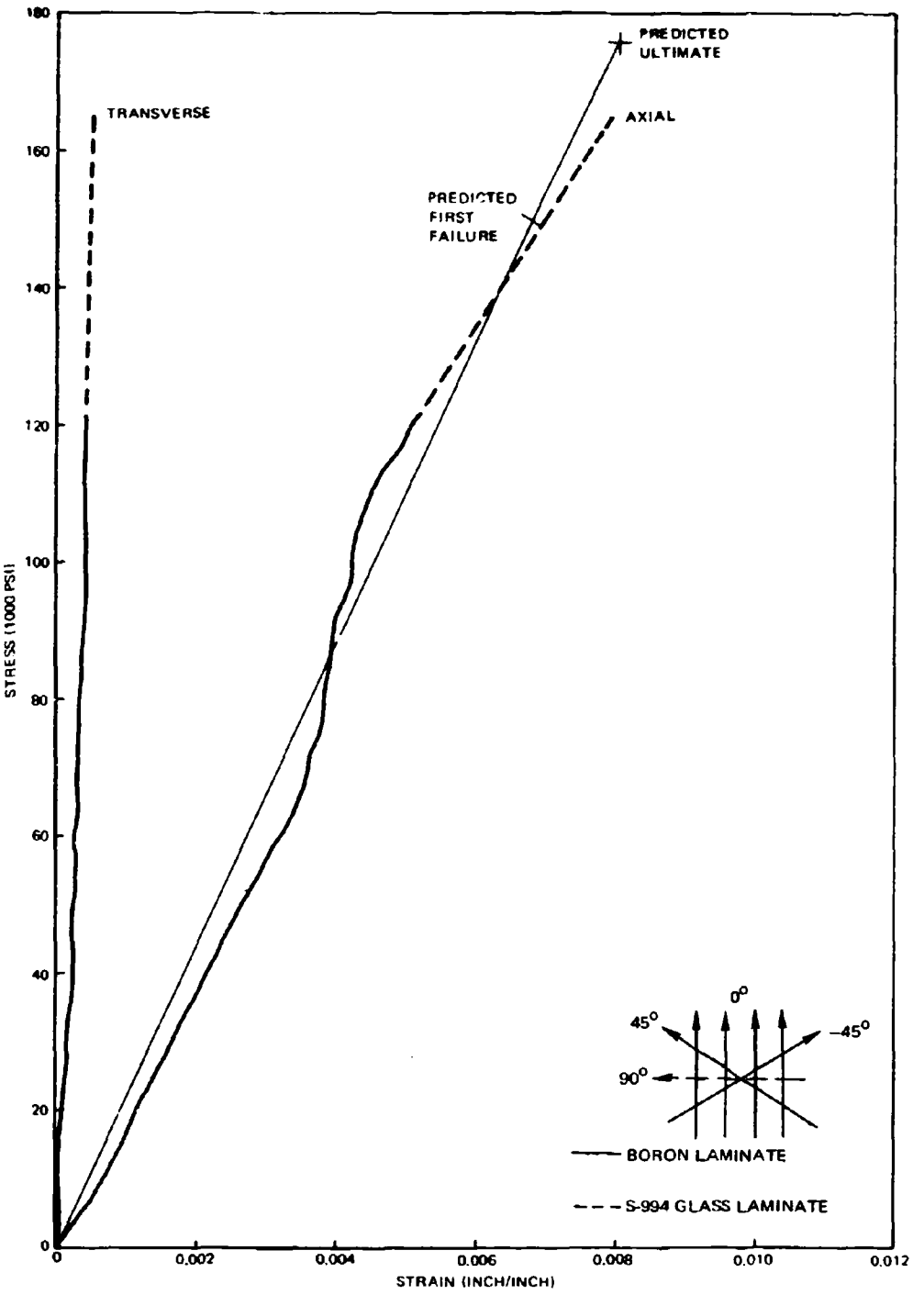


FIGURE 41. COMPRESSIVE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824818-503, NO. 2

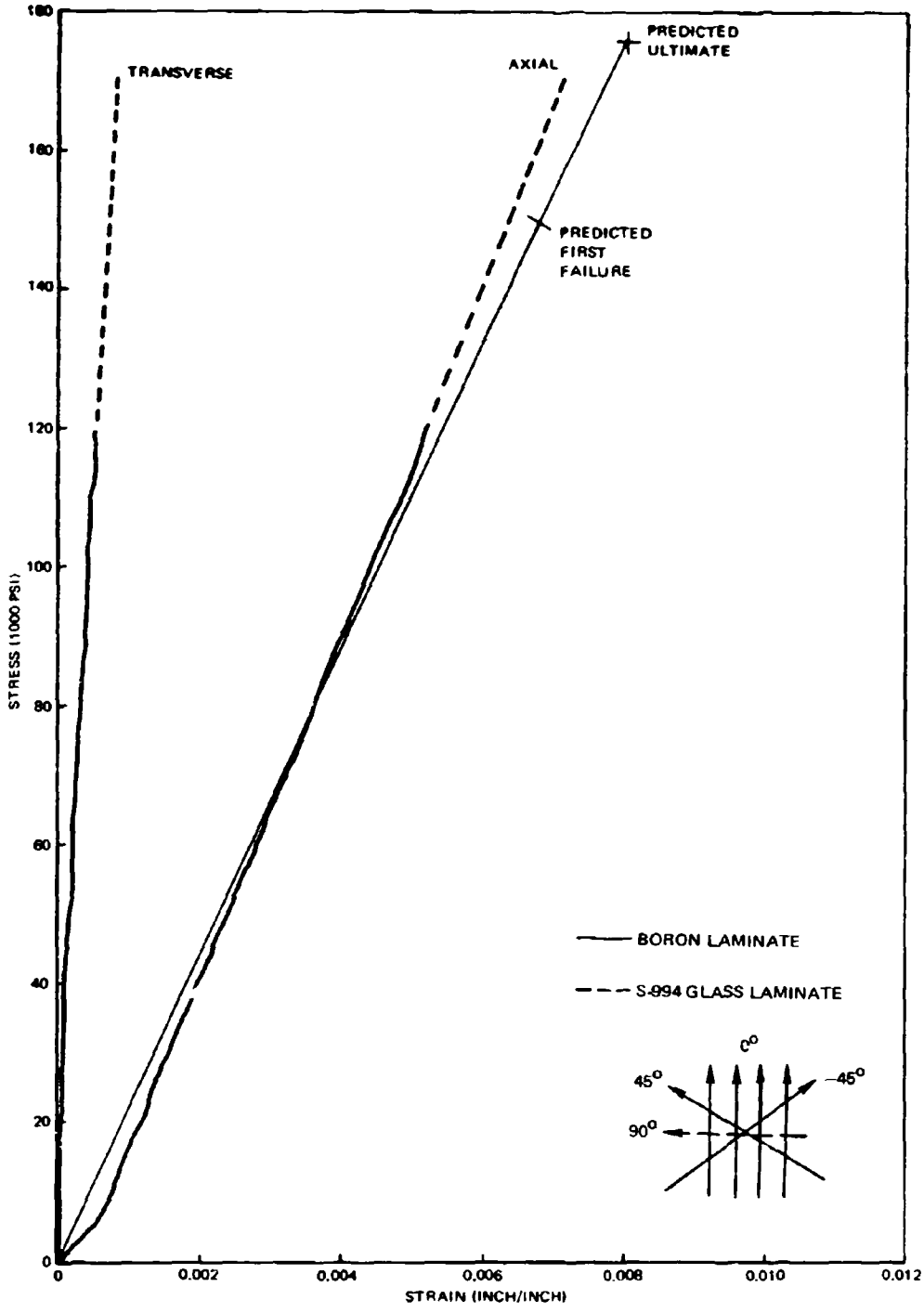


FIGURE 42. COMPRESSIVE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824818-503. NO. 3

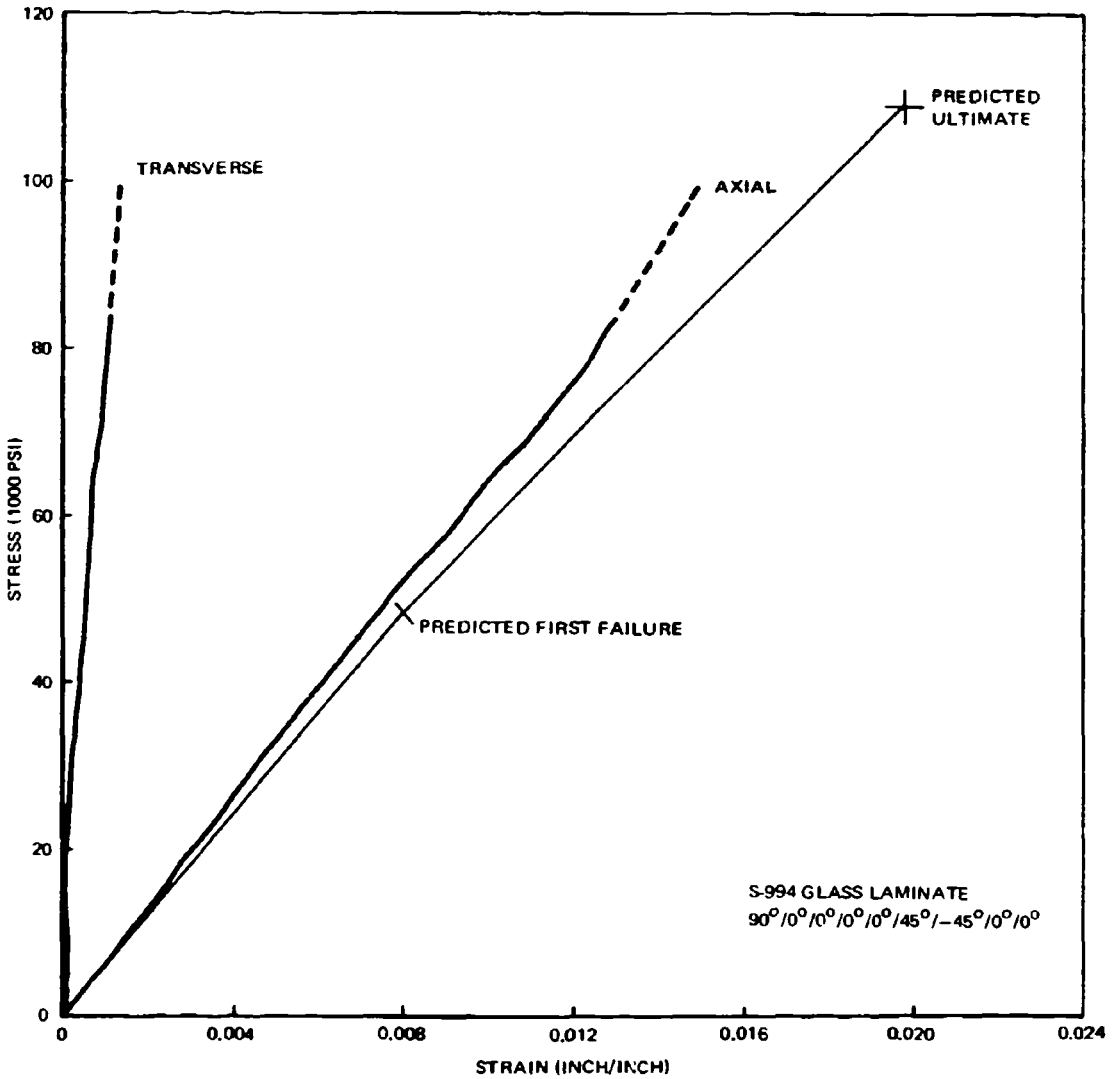


FIGURE 43. COMPRESSIVE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824818-505, NO. 1

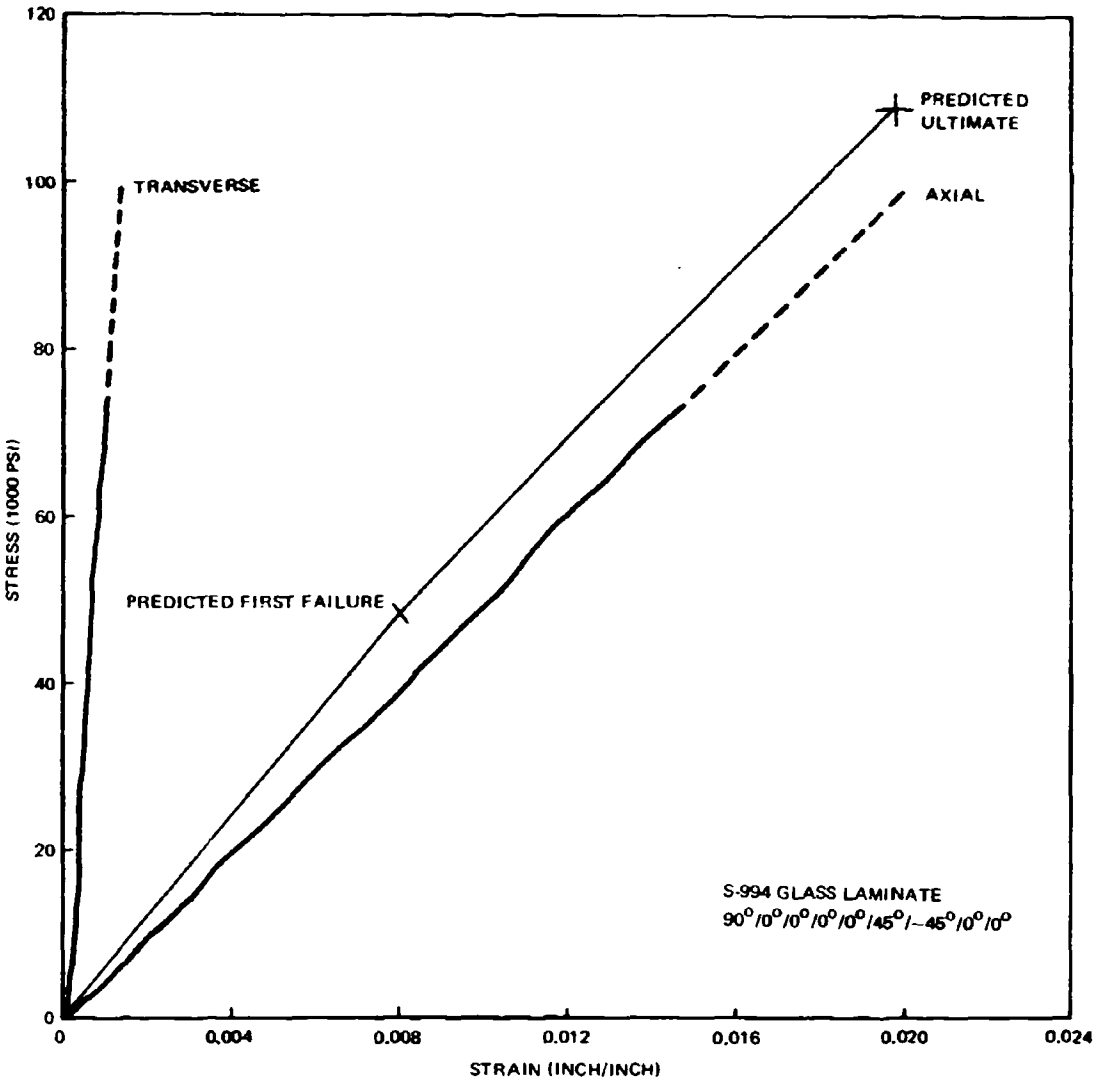


FIGURE 44. COMPRESSIVE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824818-505, NO. 2

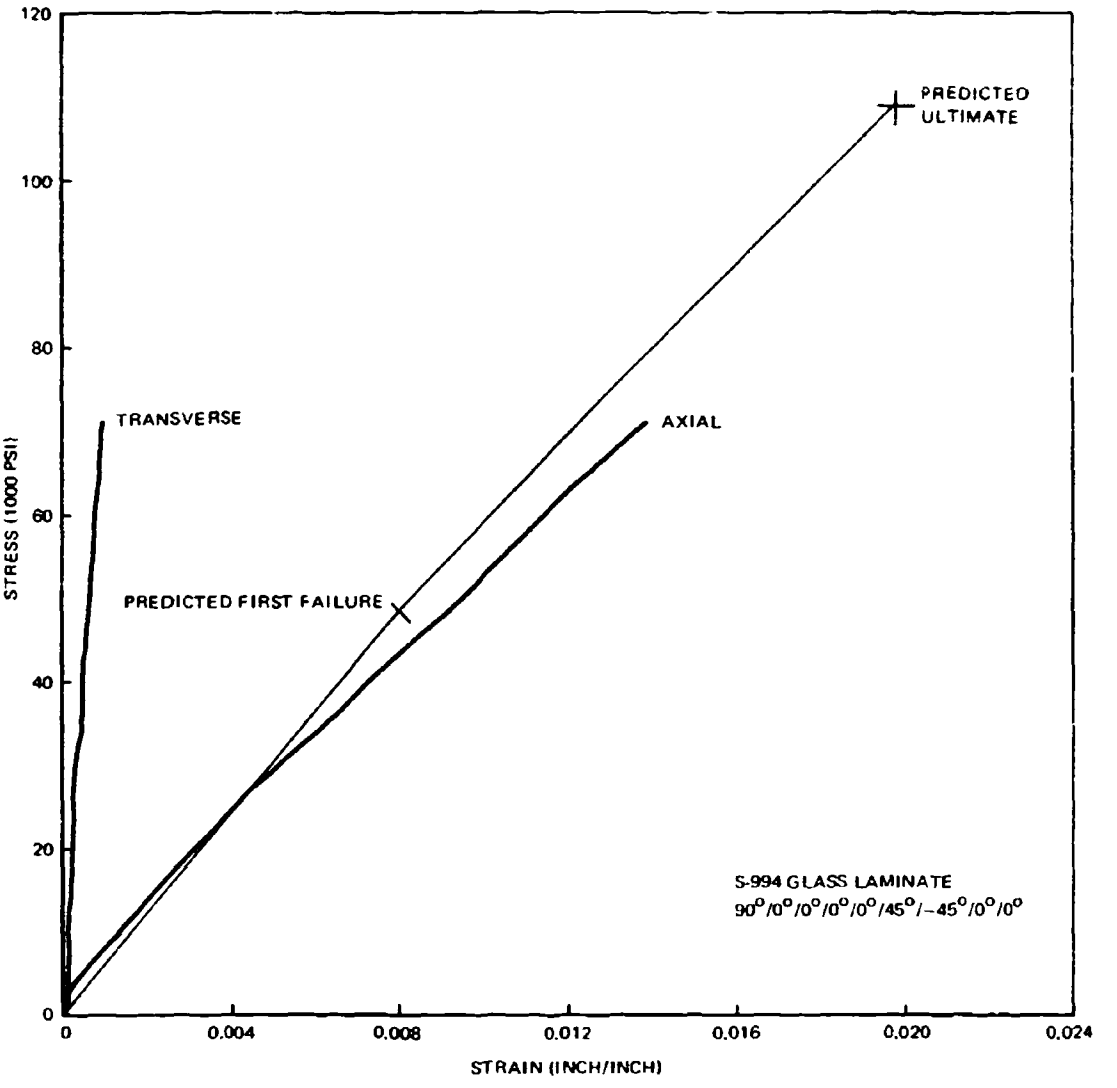


FIGURE 45. COMPRESSIVE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824818-505, NO. 3

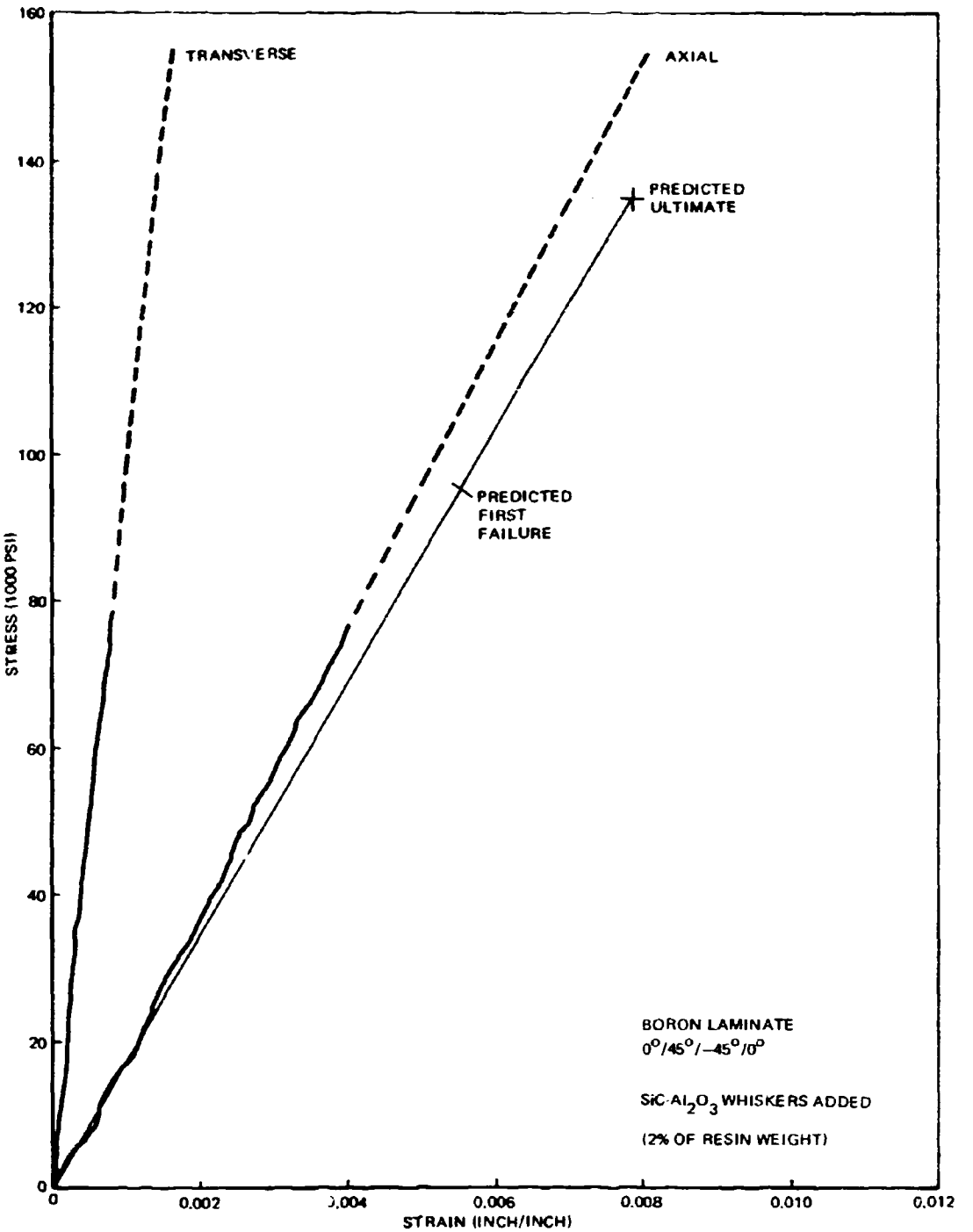


FIGURE 46. COMPRESSIVE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824818-507, NO. 1

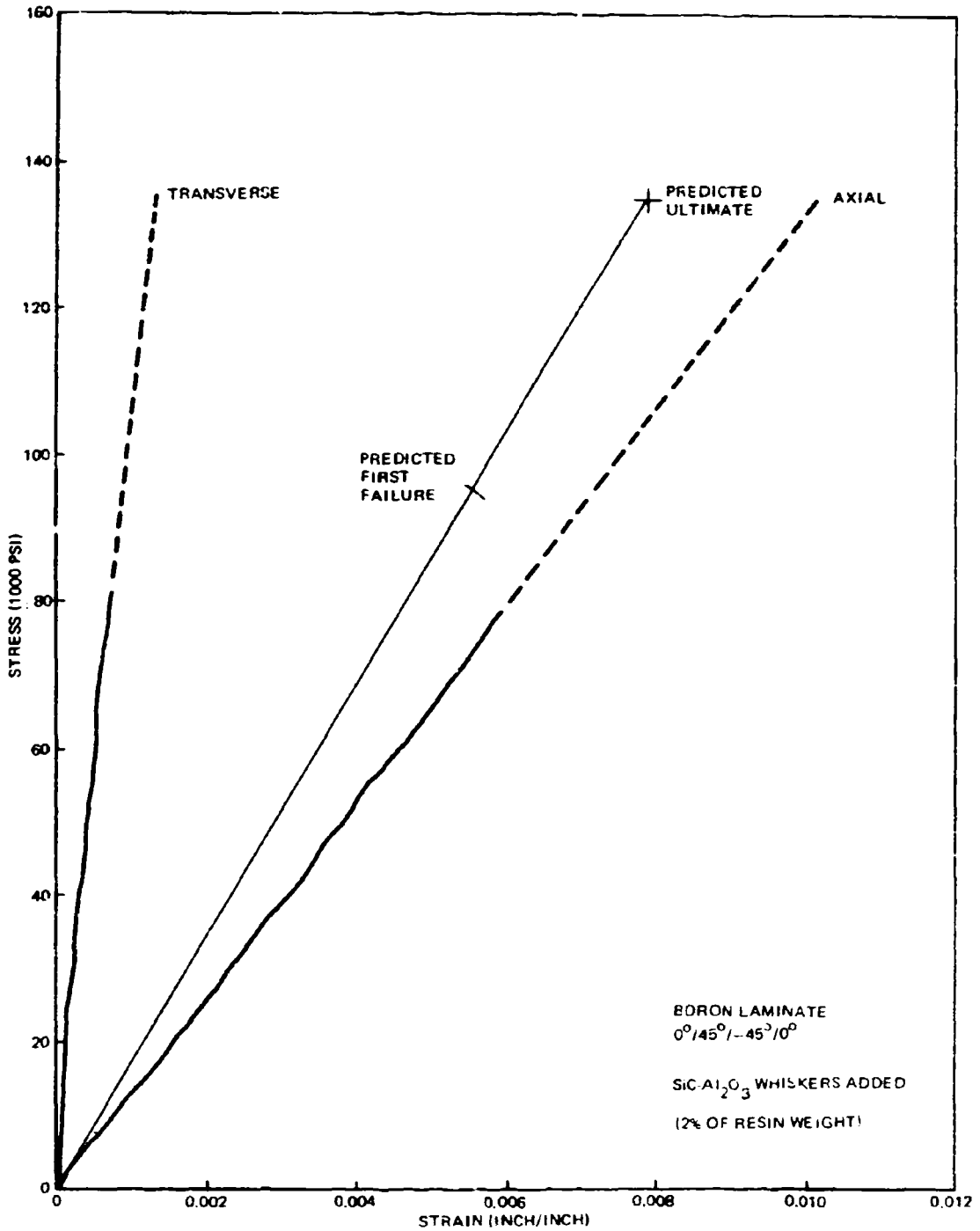


FIGURE 47. COMPRESSIVE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824818-507, NO. 2

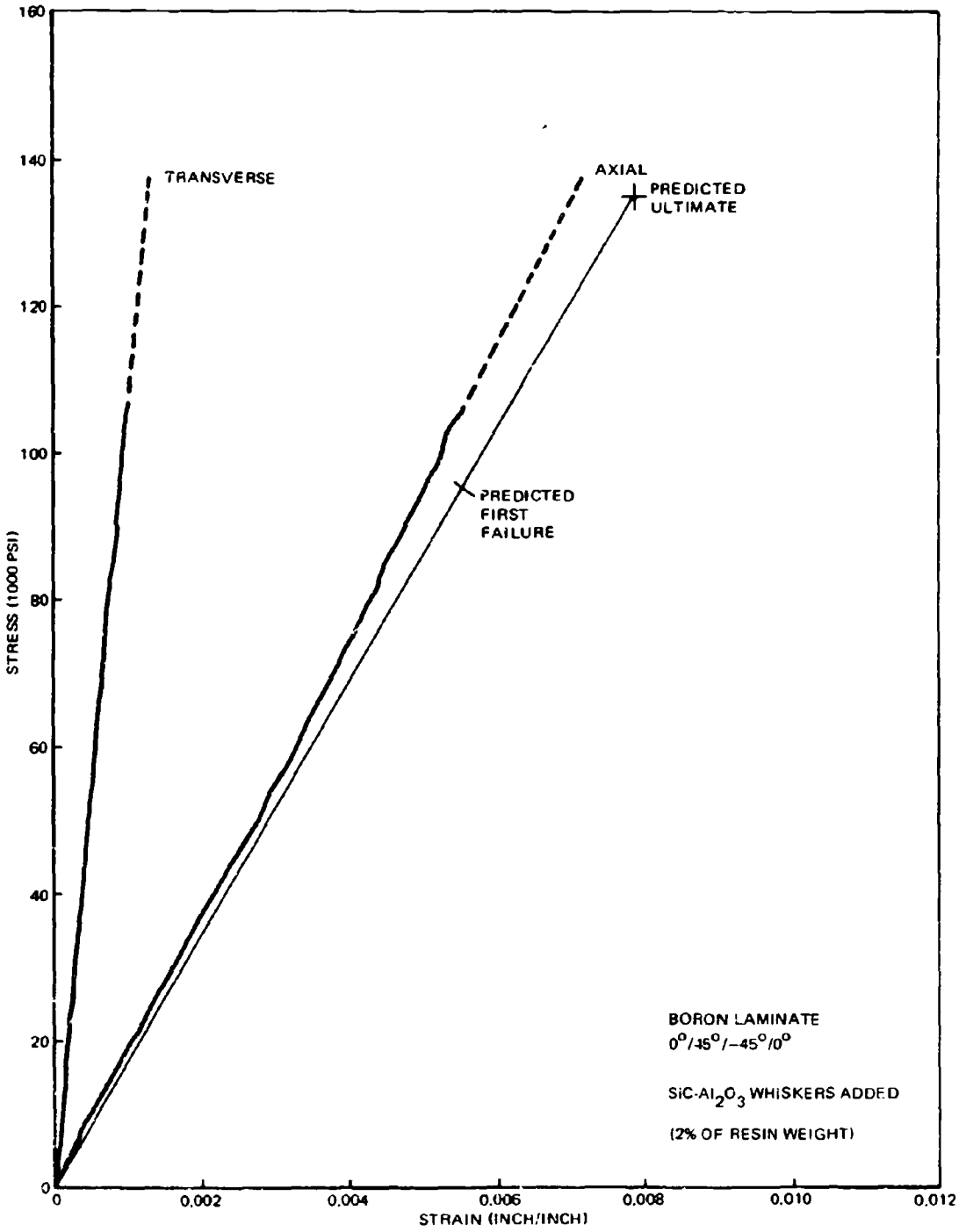


FIGURE 48. COMPRESSIVE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824818-507, NO. 3

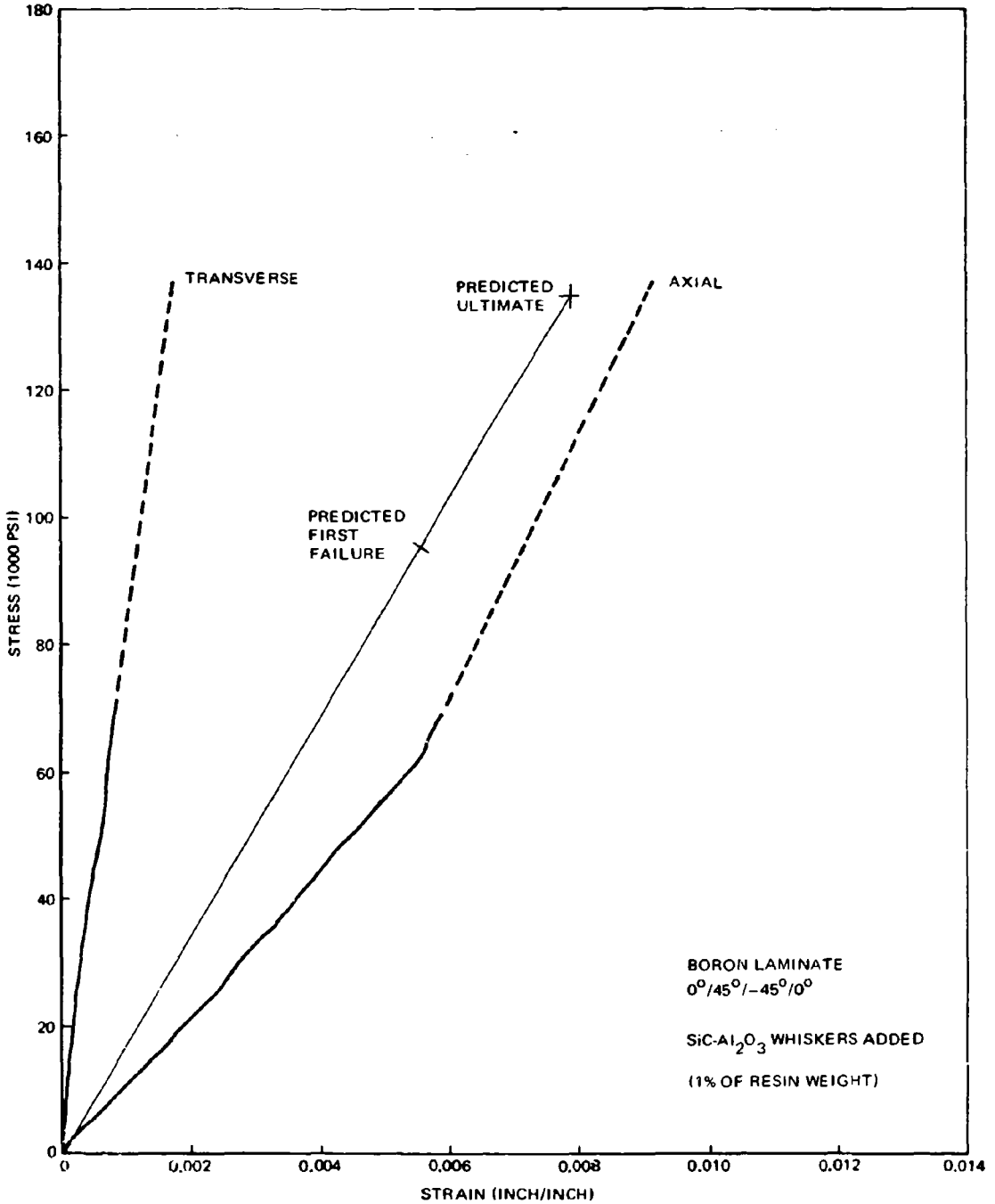


FIGURE 49. COMPRESSIVE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824818-509, NO. 1

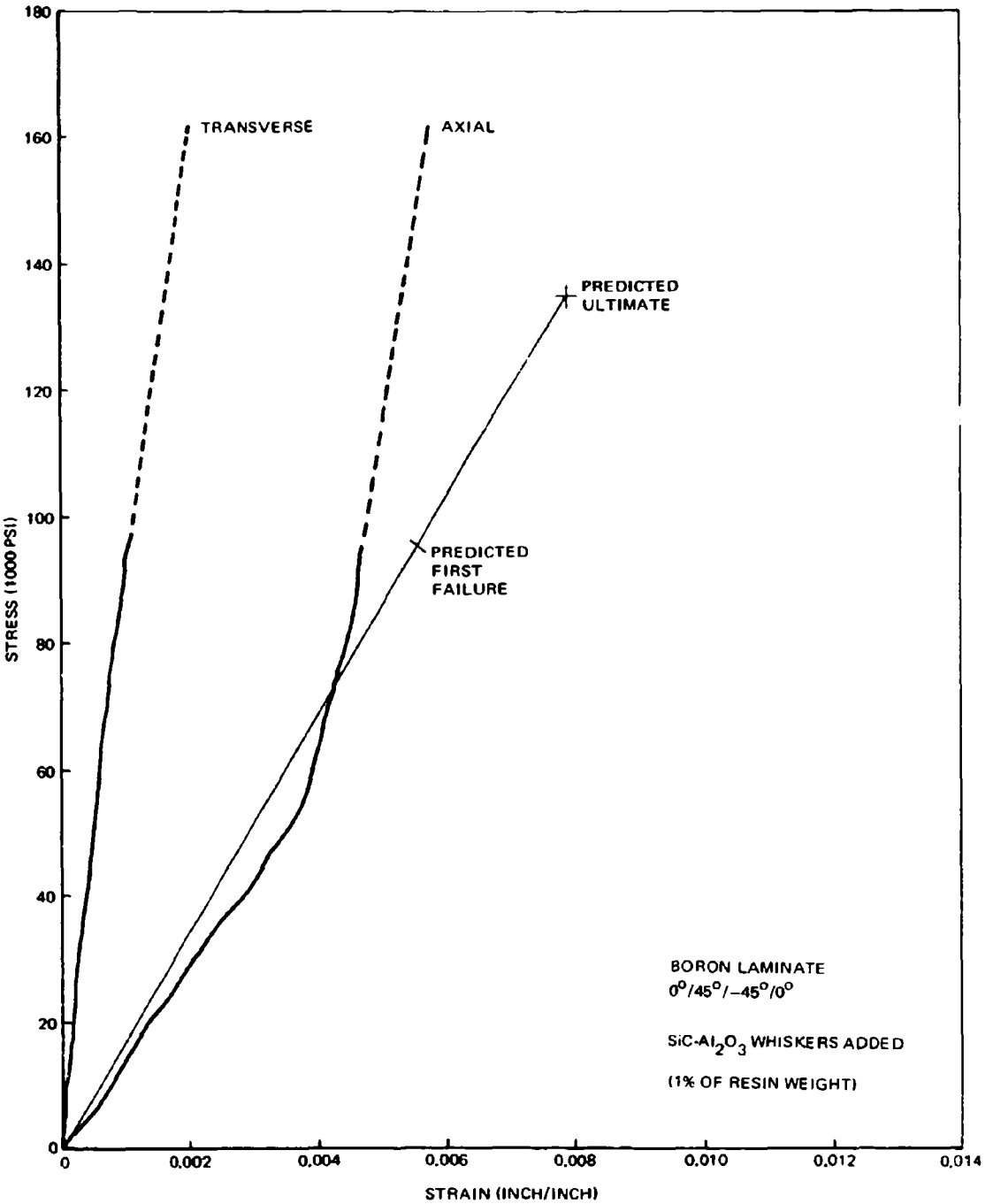


FIGURE 50. COMPRESSIVE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824818-509, NO. 2

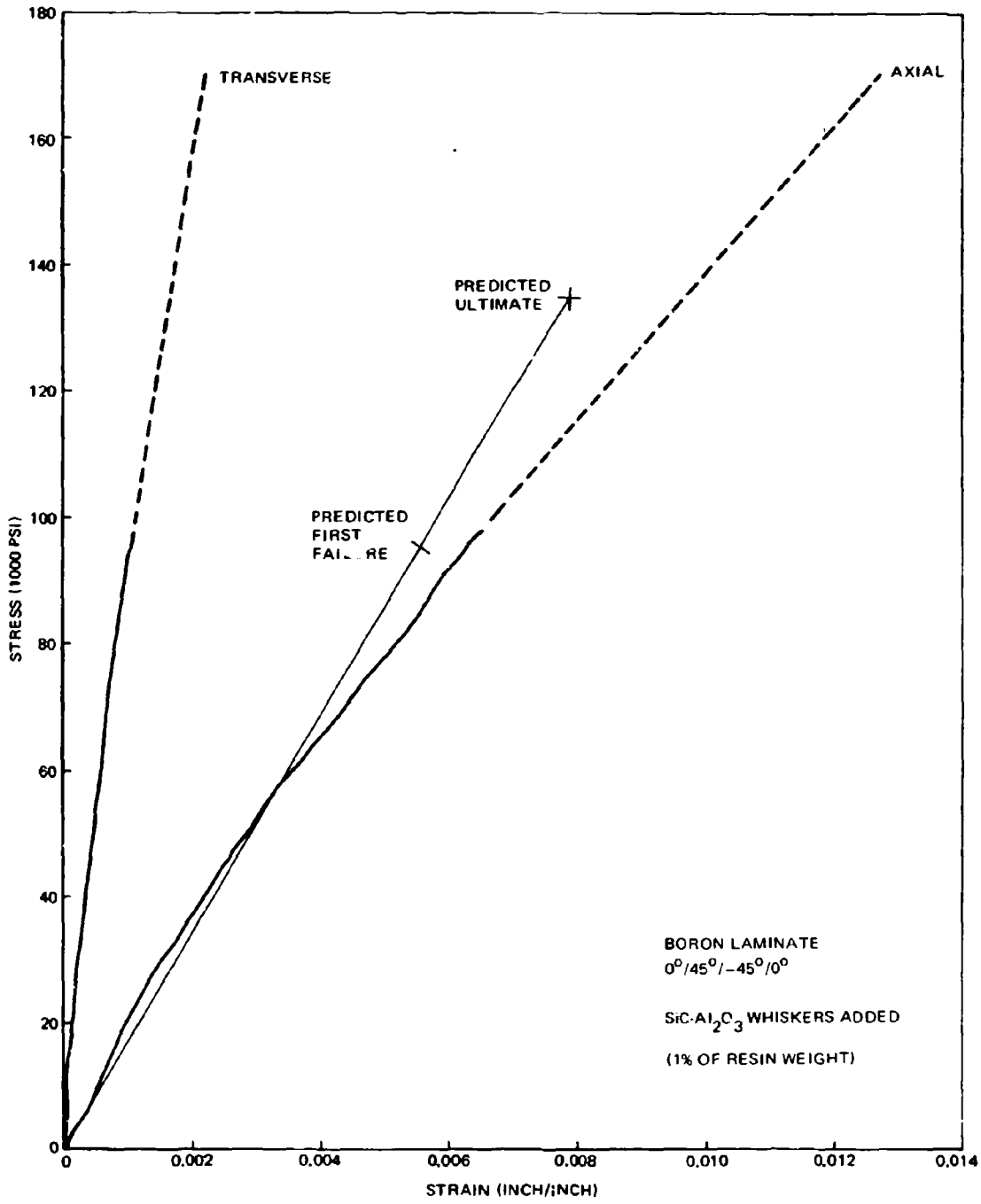


FIGURE 51. COMPRESSIVE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824818-509, NO. 3

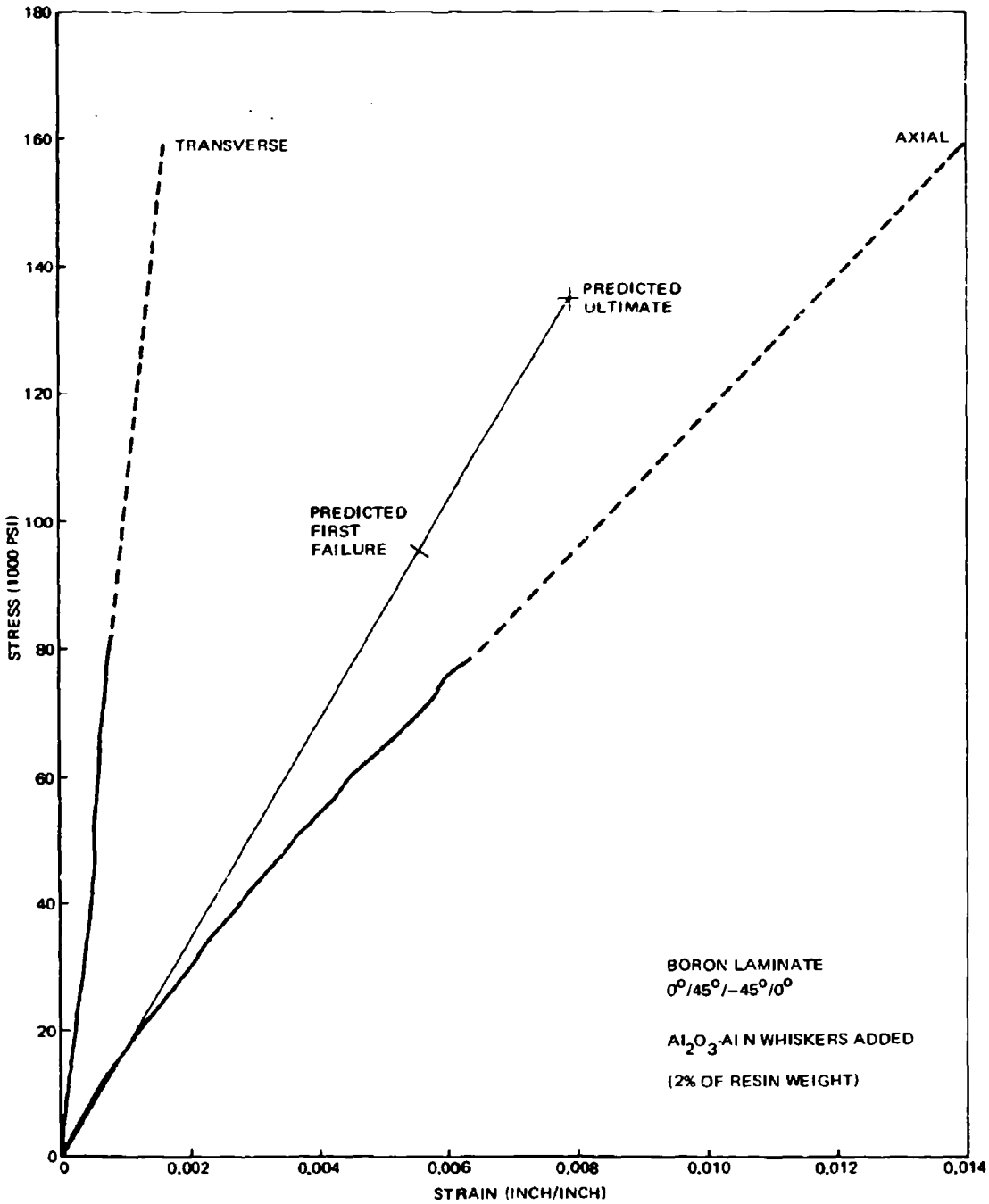


FIGURE 52. COMPRESSIVE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824813-515, NO. 1

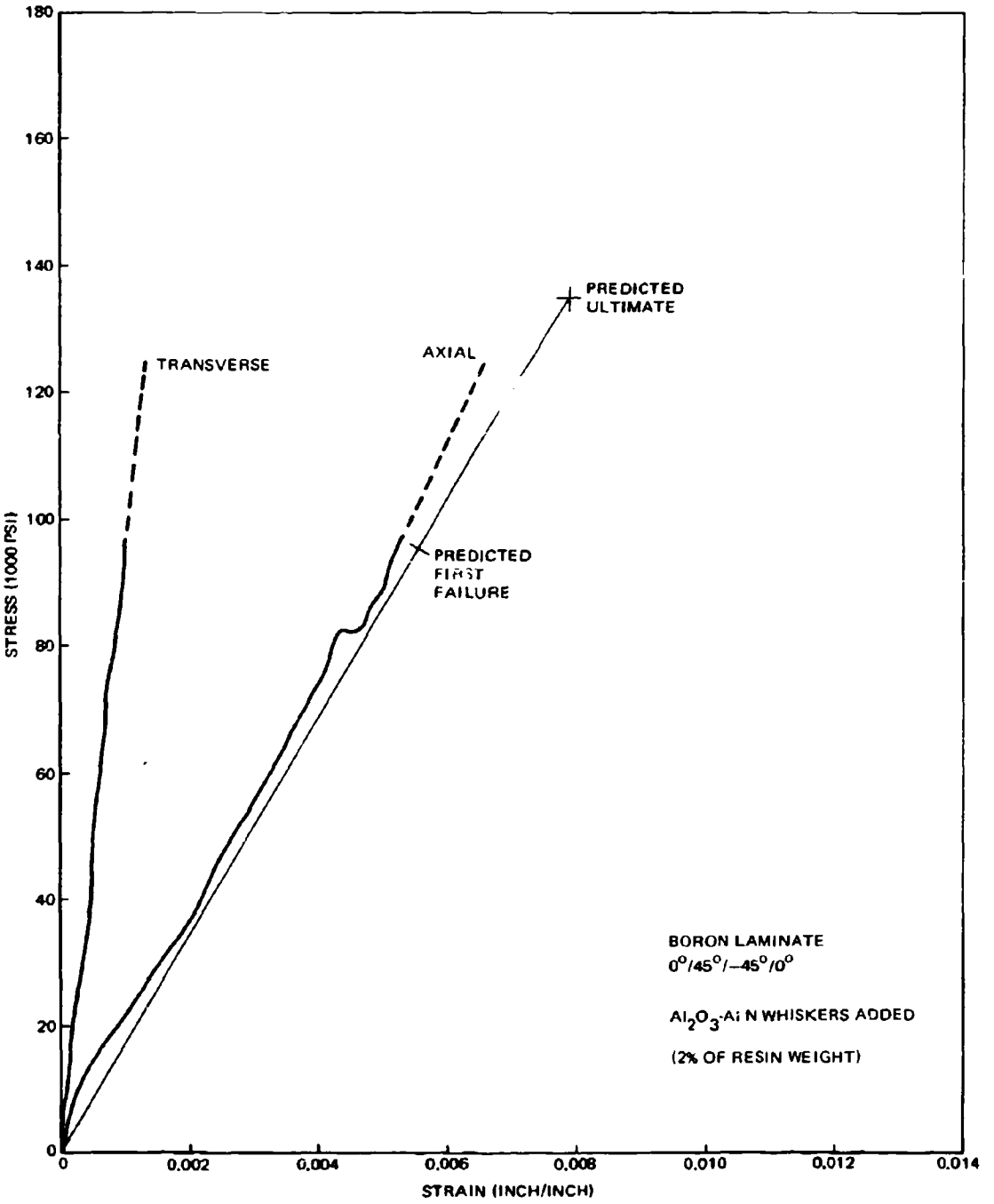


FIGURE 53. COMPRESSIVE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824813-515, NO. 2

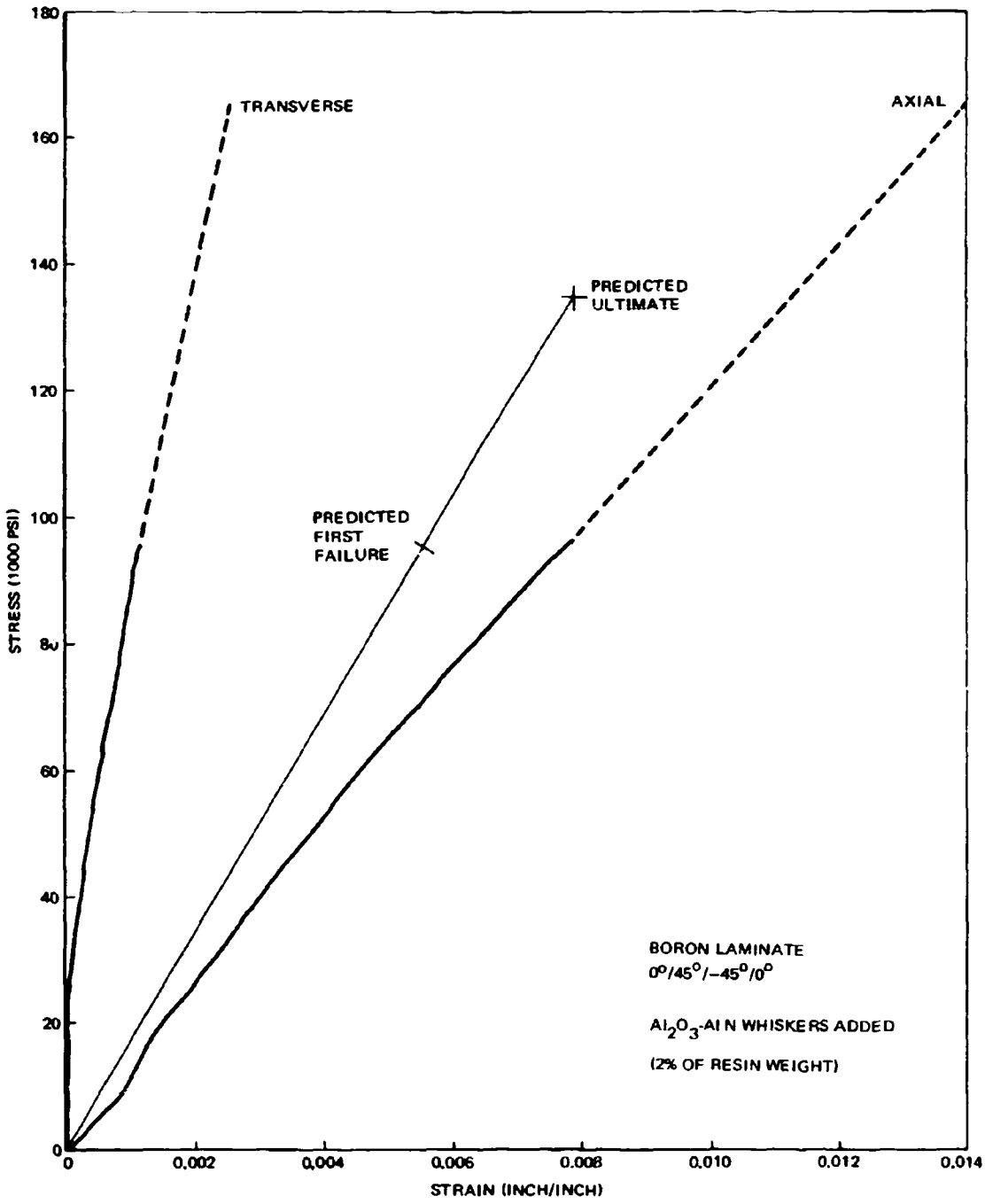
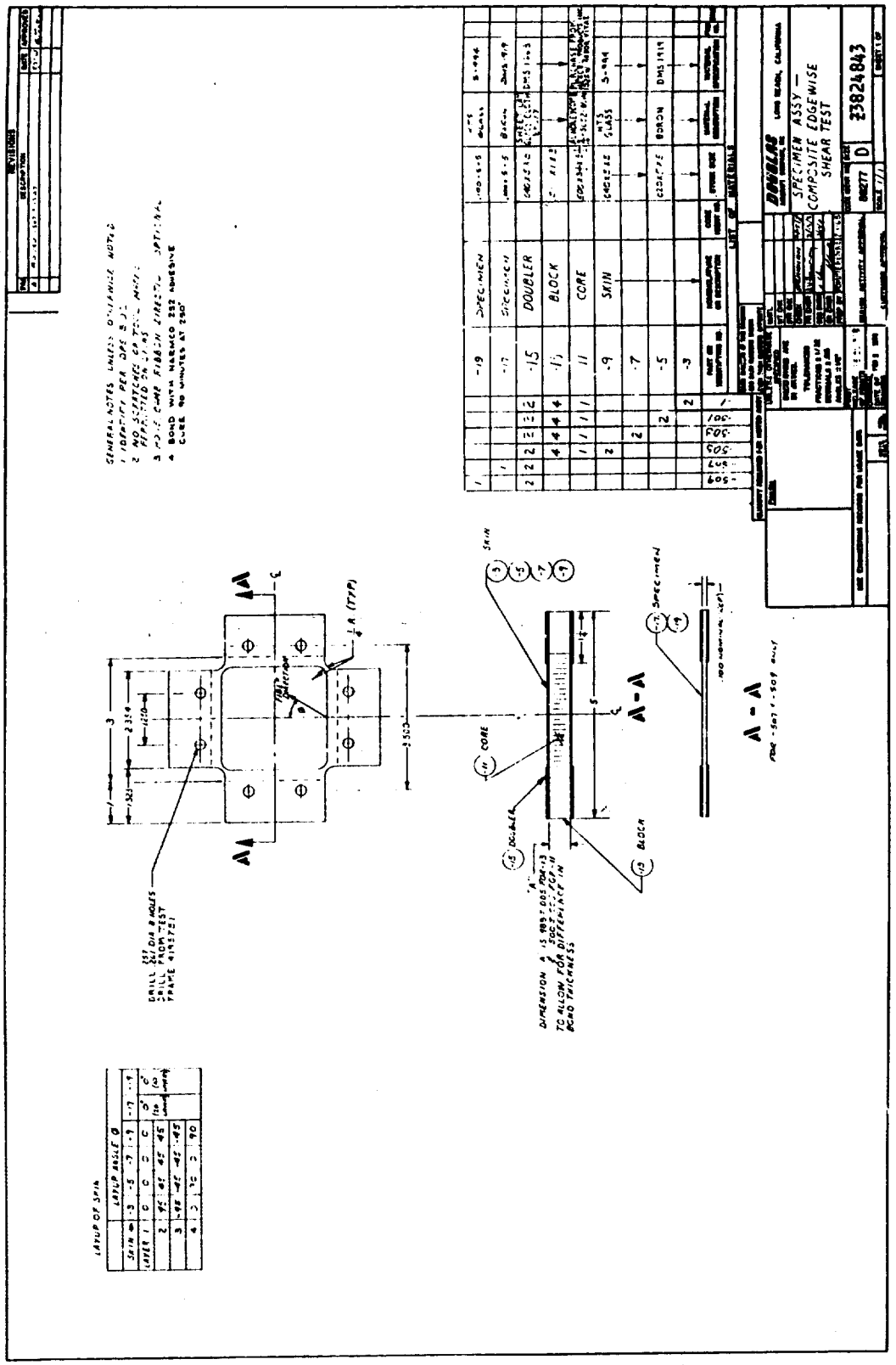


FIGURE 54. COMPRESSIVE STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824813-515, NO. 3



DRAWING Z3824843. SPECIMEN ASSEMBLY – COMPOSITE EDGEWISE SHEAR TEST

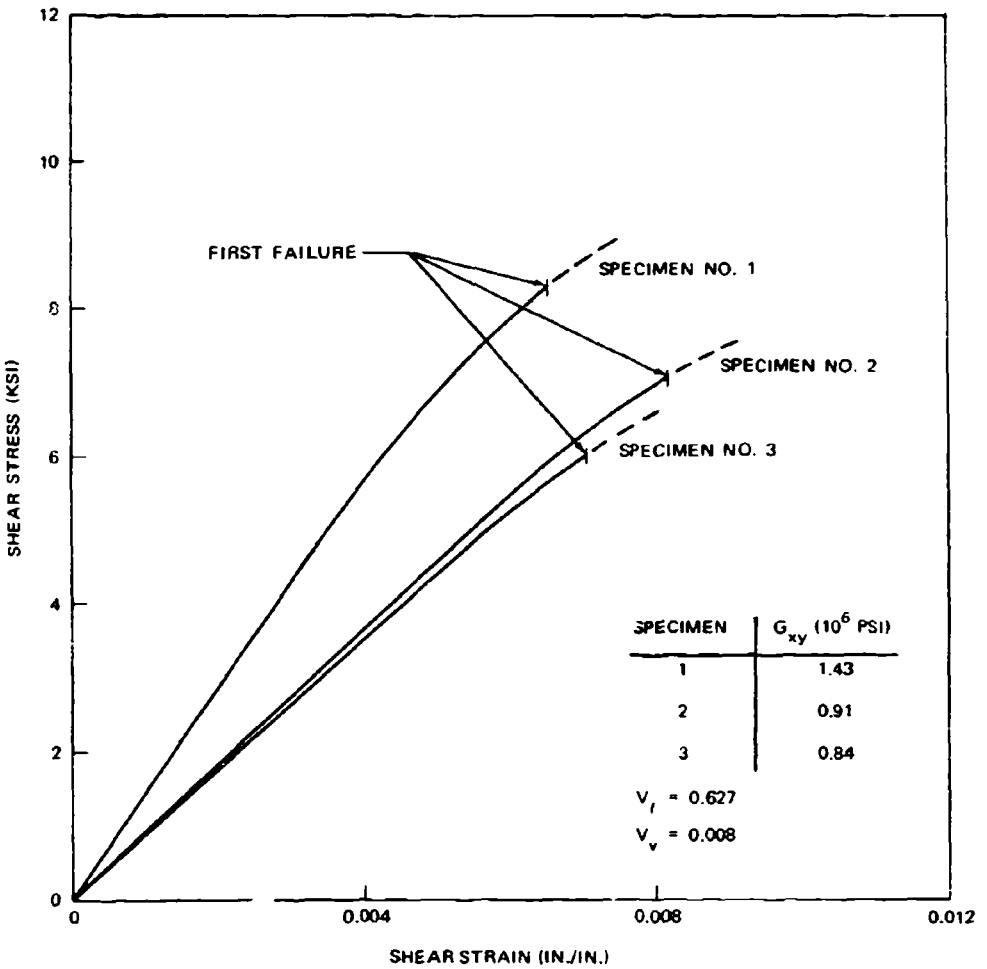


FIGURE 55. EDGEWISE SHEAR STRESS-STRAIN DIAGRAM FOR UNIDIRECTIONAL S-994 FIBER GLASS-NARMCO 5505 LAMINATES

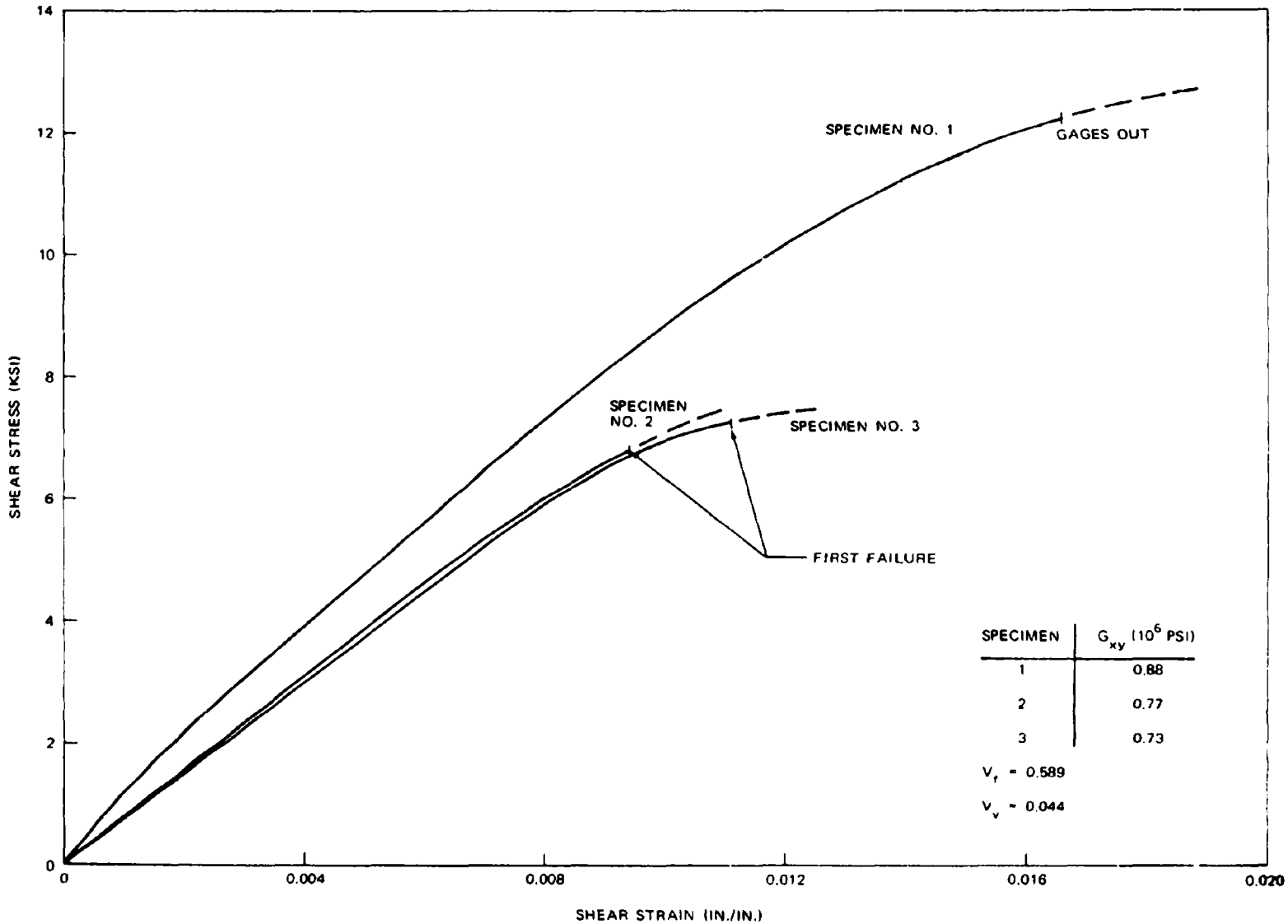


FIGURE 56. EDGEWISE SHEAR STRESS-STRAIN DIAGRAM FOR UNIDIRECTIONAL BORON-NARMCO 5505 LAMINATES

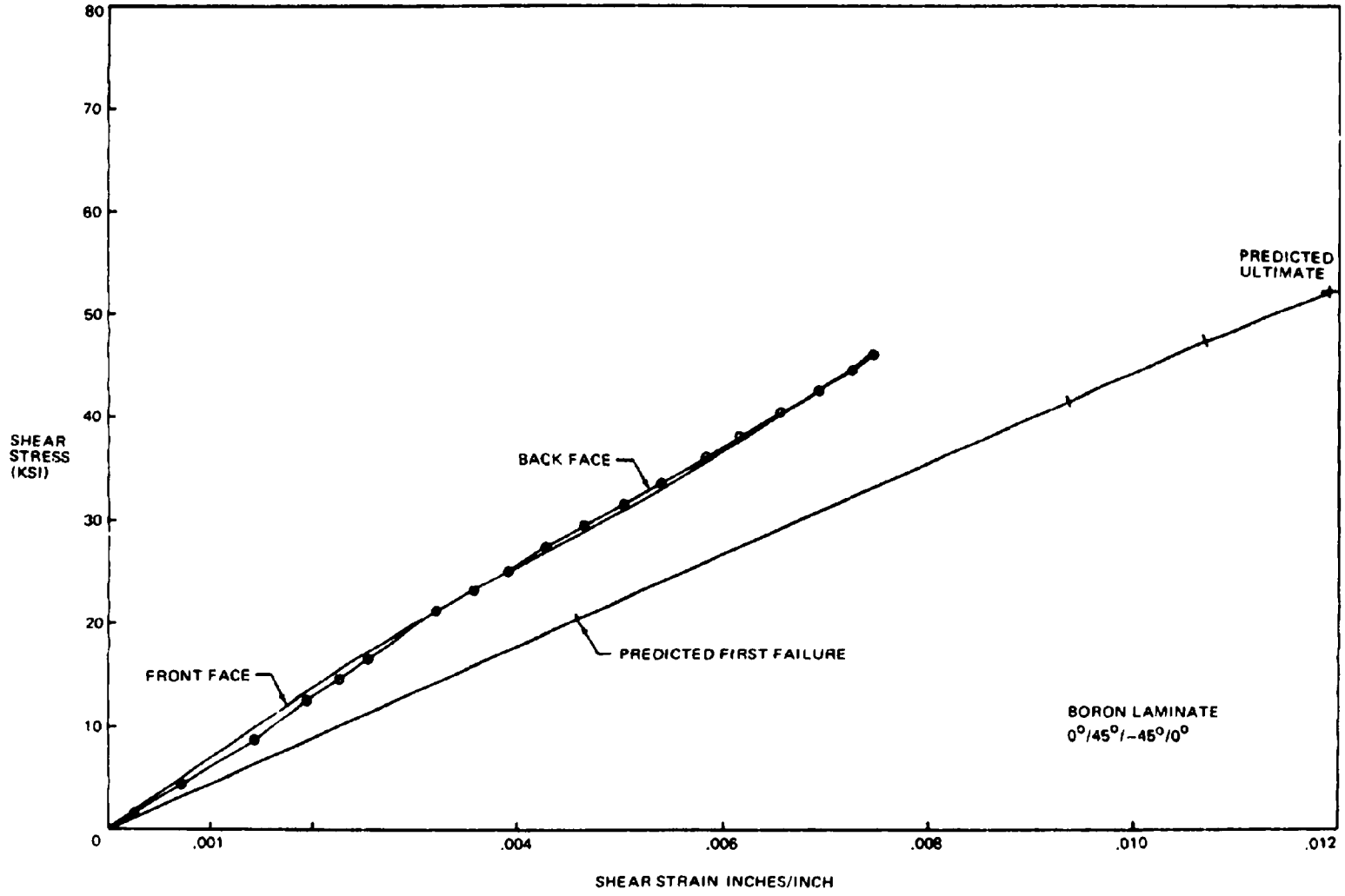


FIGURE 57. EDGEWISE SHEAR STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824843-1, NO. 1

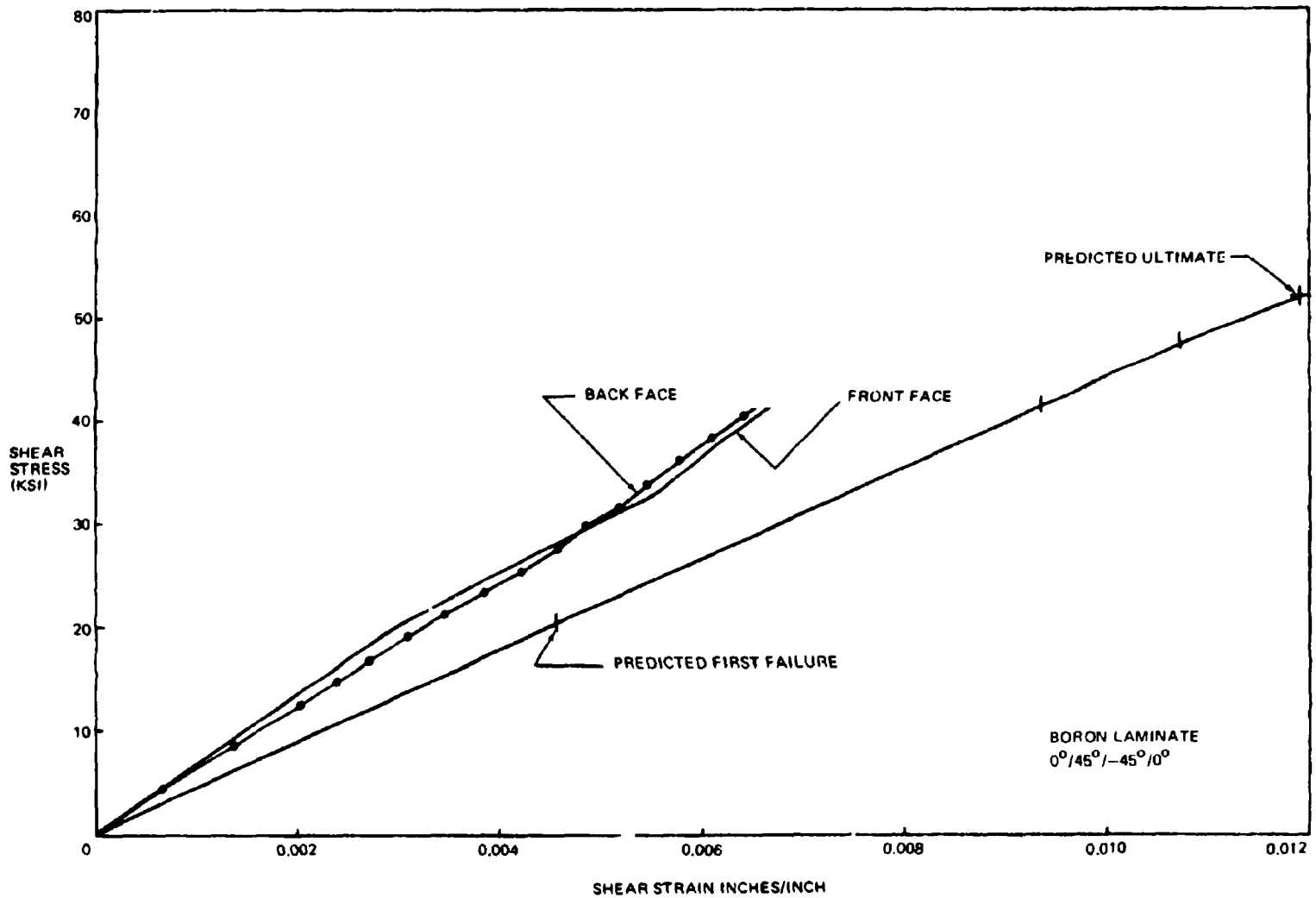


FIGURE 58. EDGEWISE SHEAR STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824843-1, NO. 2

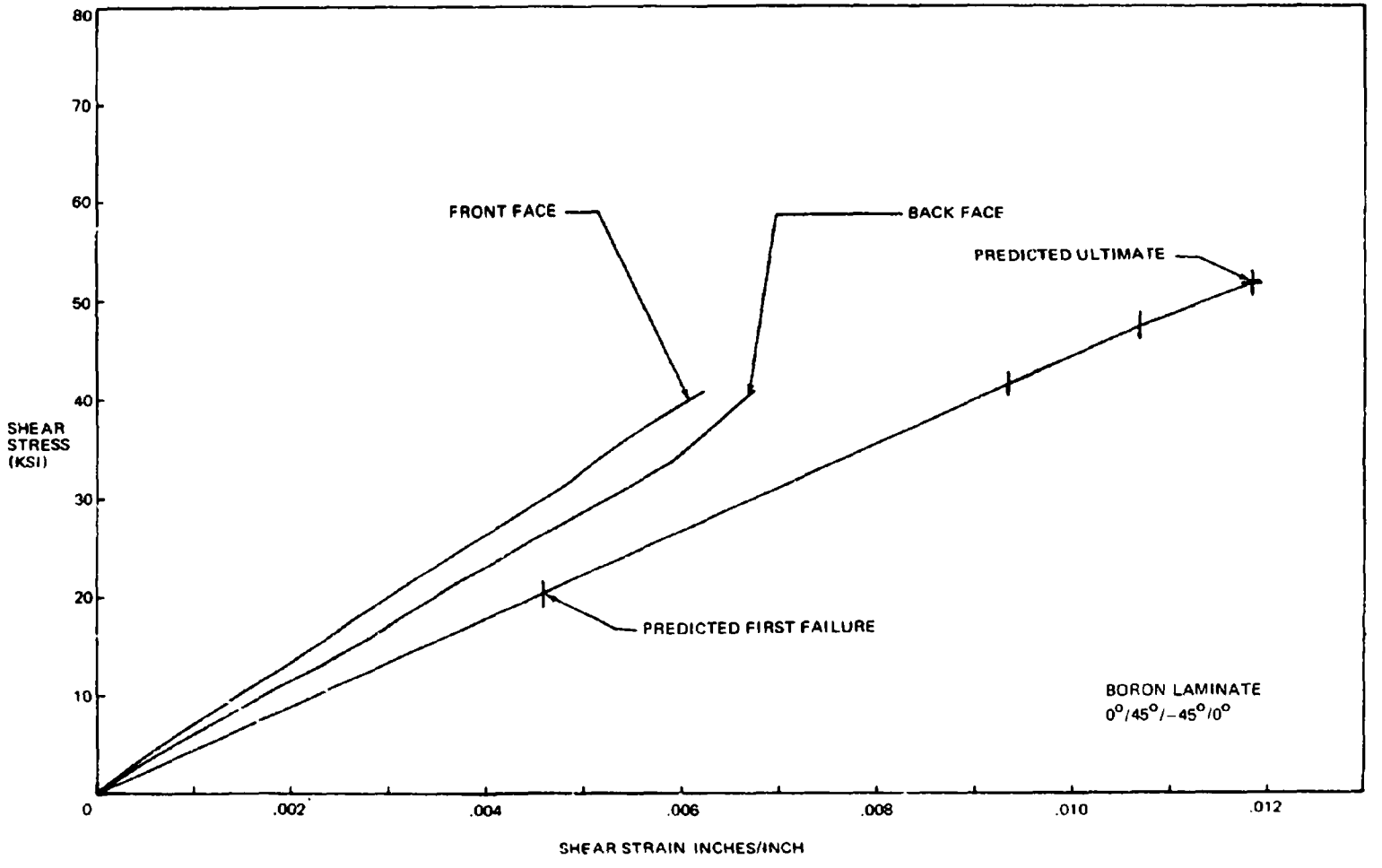


FIGURE 59. EDGEWISE SHEAR STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824843-1, NO. 3

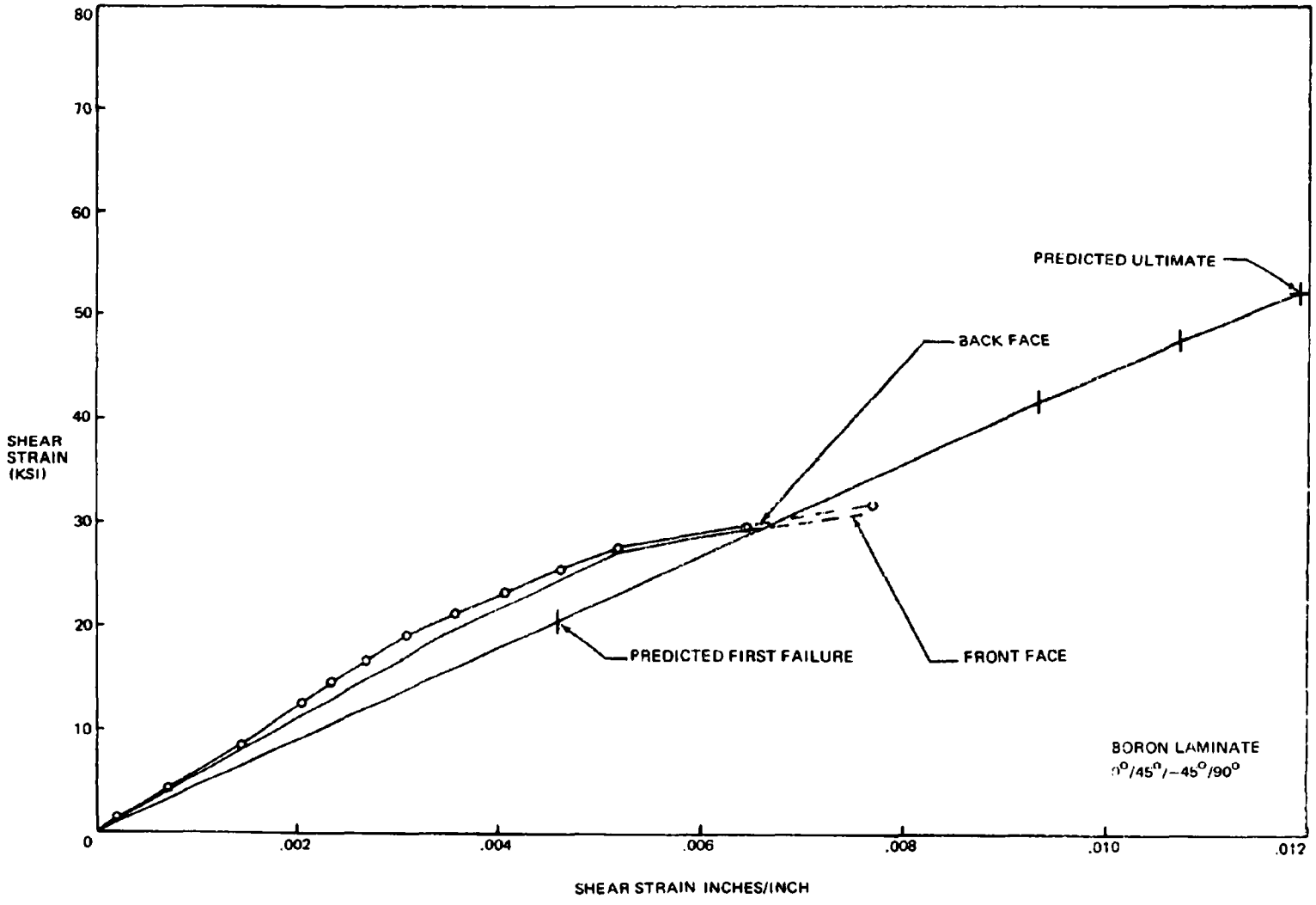


FIGURE 60. EDGEWISE SHEAR STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824843-501, NO. 1

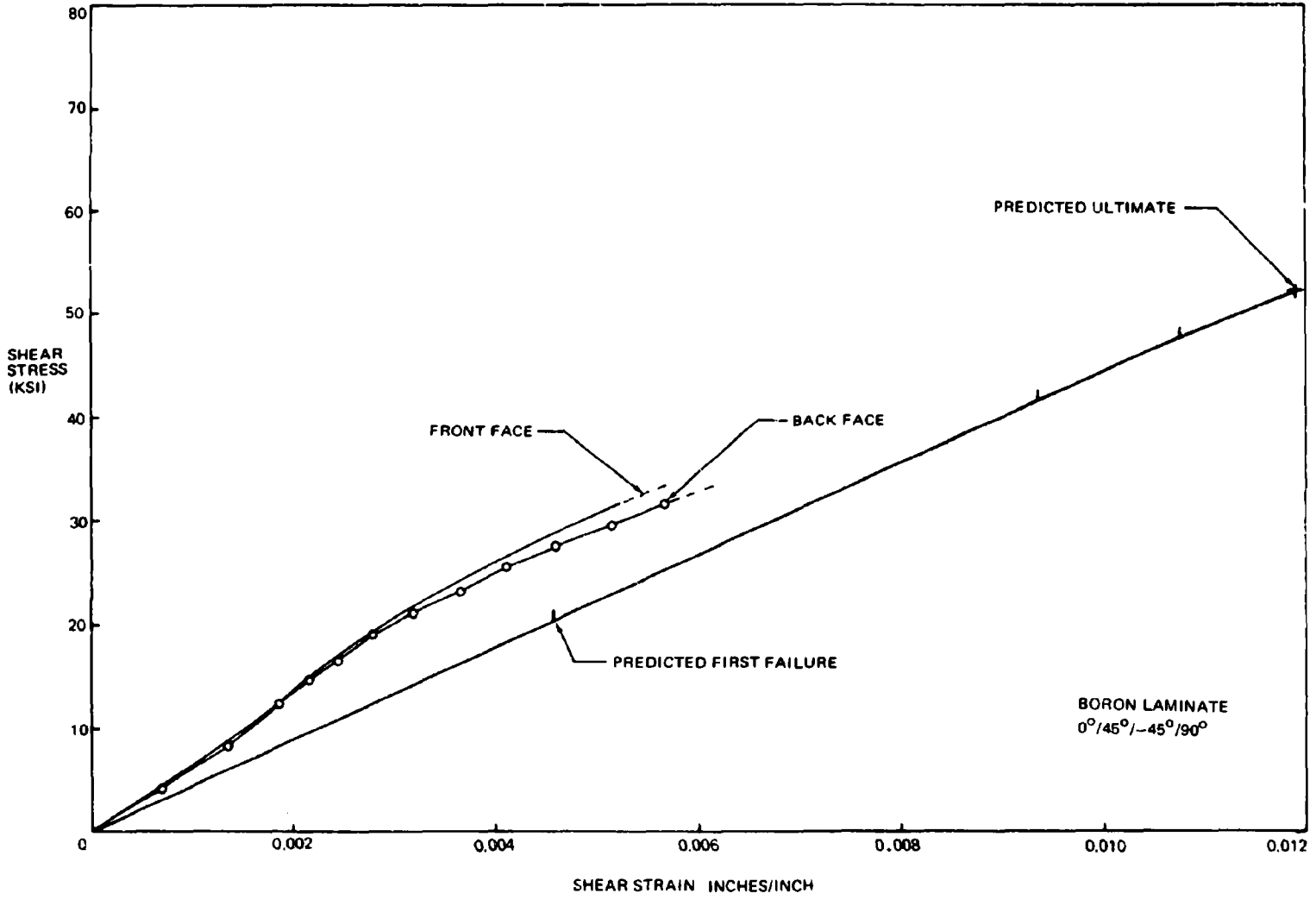


FIGURE 61. EDGEWISE SHEAR STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824843-501, NO. 2

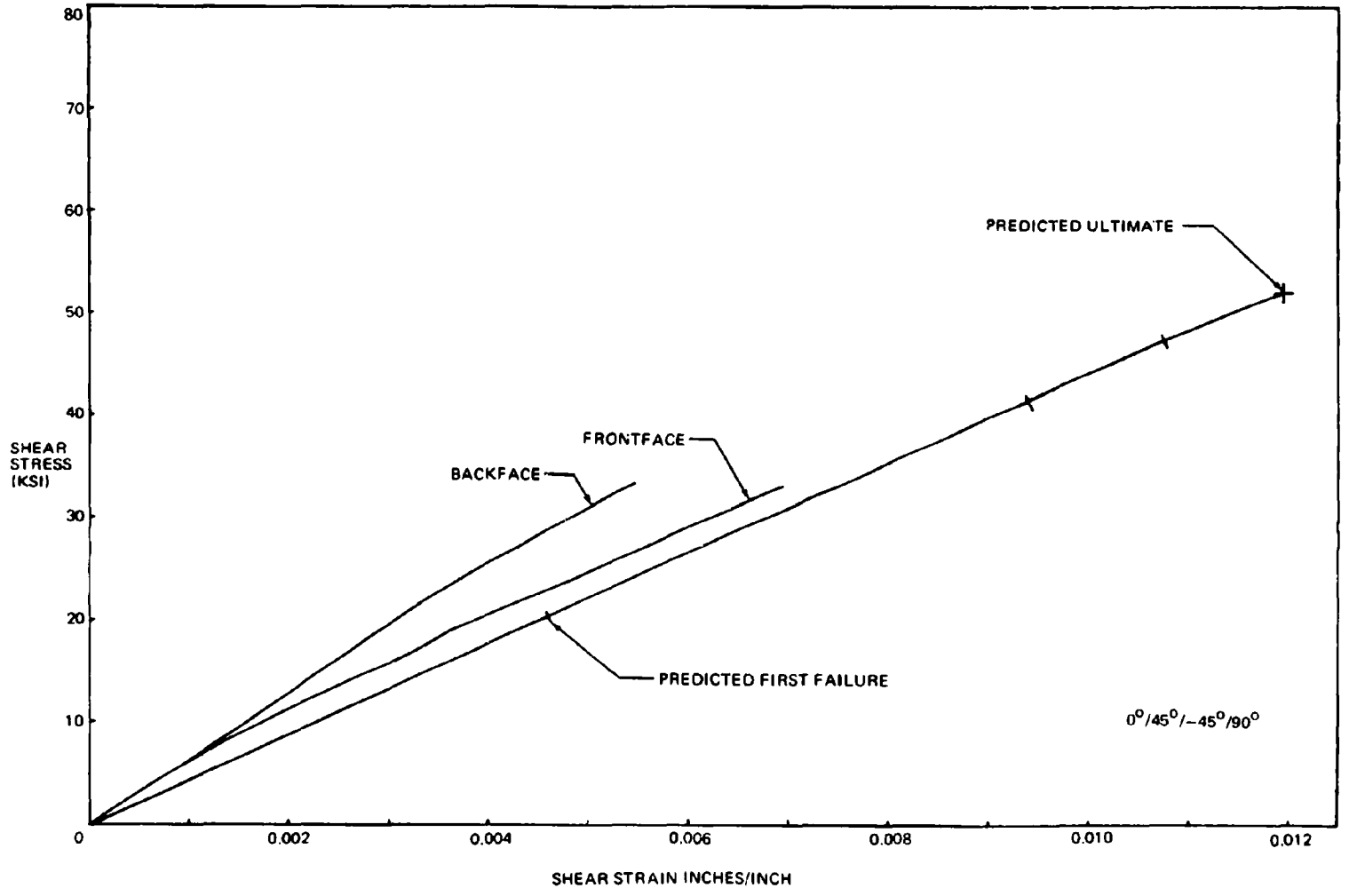


FIGURE 62. EDGEWISE SHEAR STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824843-501, NO. 3

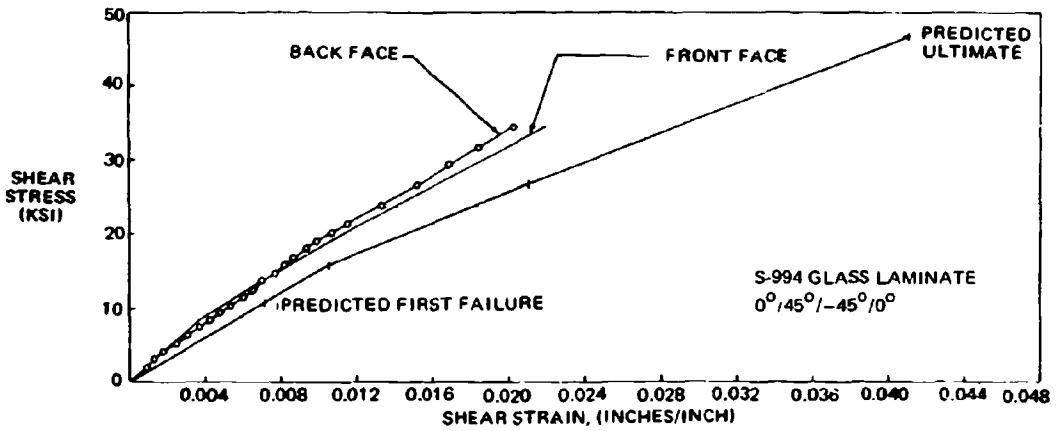


FIGURE 63. EDGEWISE SHEAR STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824843-503, NO. 1

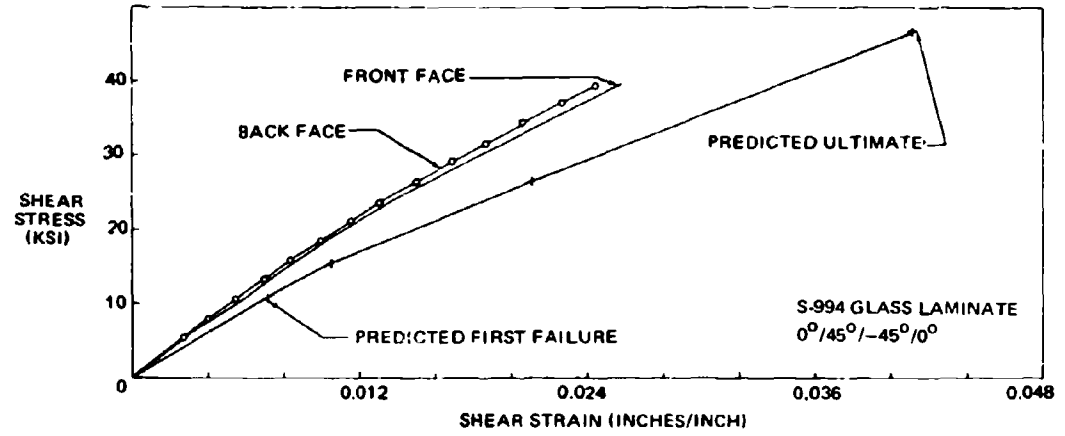


FIGURE 64. EDGEWISE SHEAR STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824843-503, NO. 2

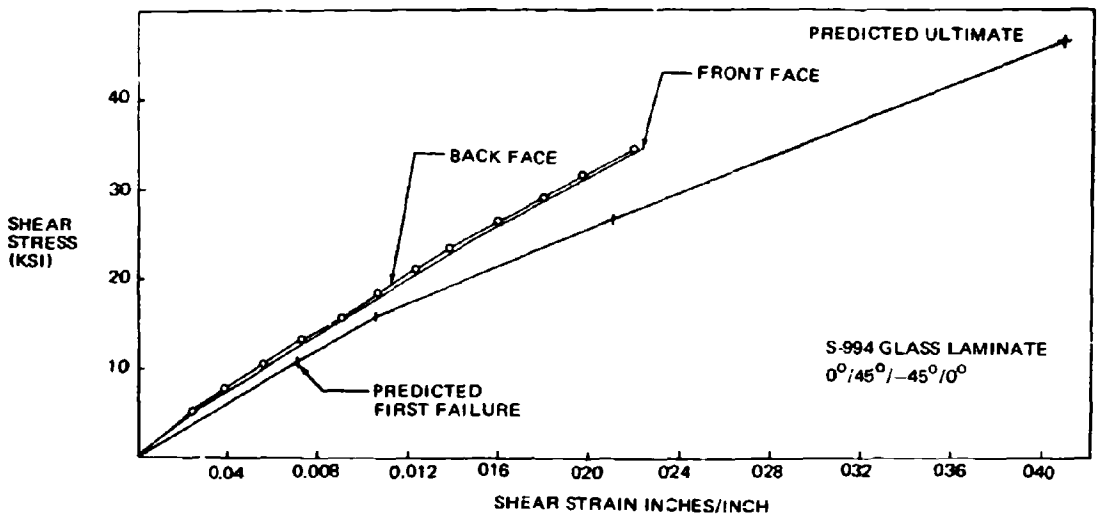


FIGURE 65. EDGEWISE SHEAR STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824843-503, NO. 3

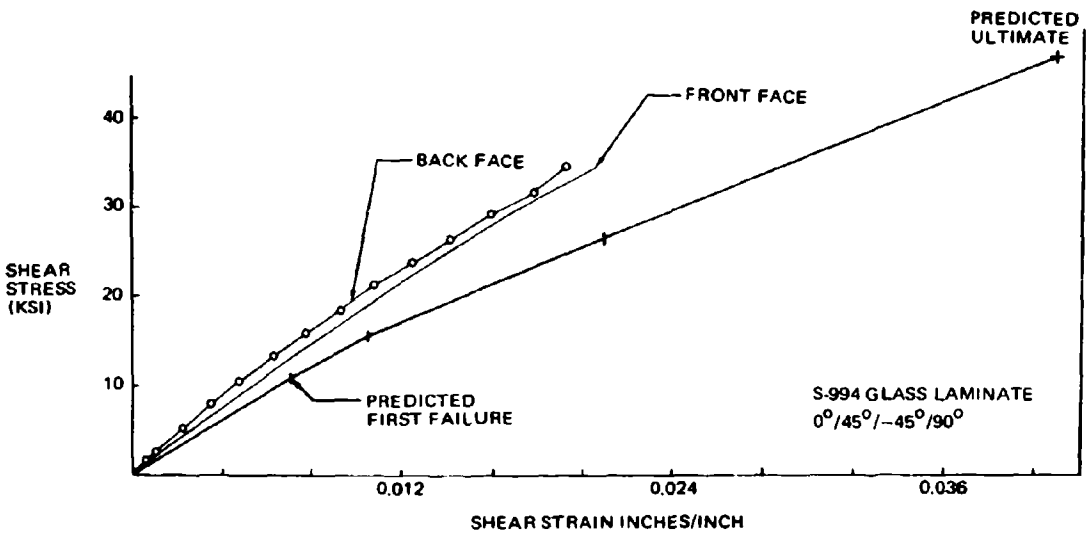


FIGURE 66. EDGEWISE SHEAR STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824843-505, NO. 1

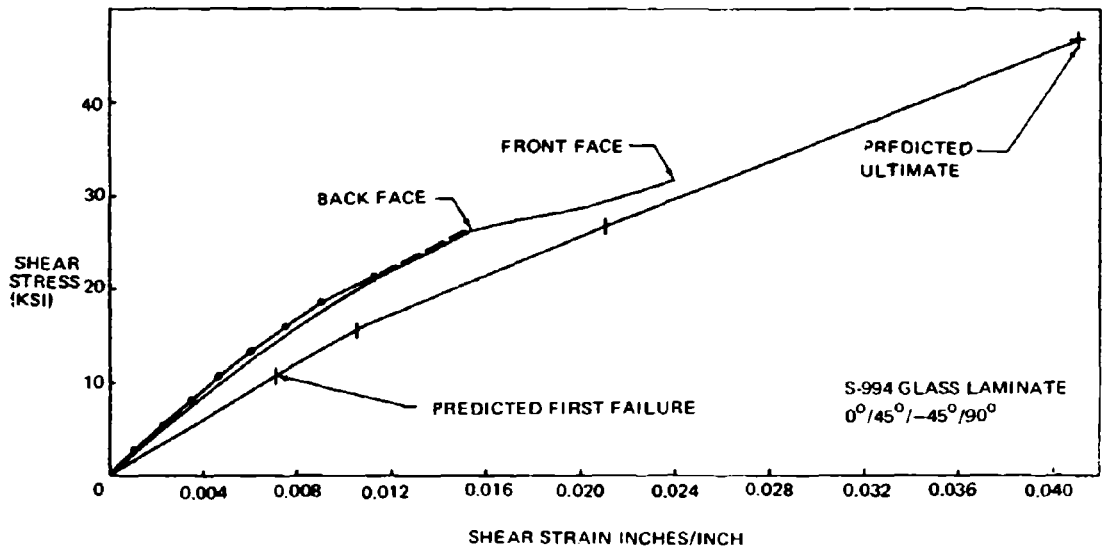


FIGURE 67. EDGEWISE SHEAR STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824843-505, NO. 2

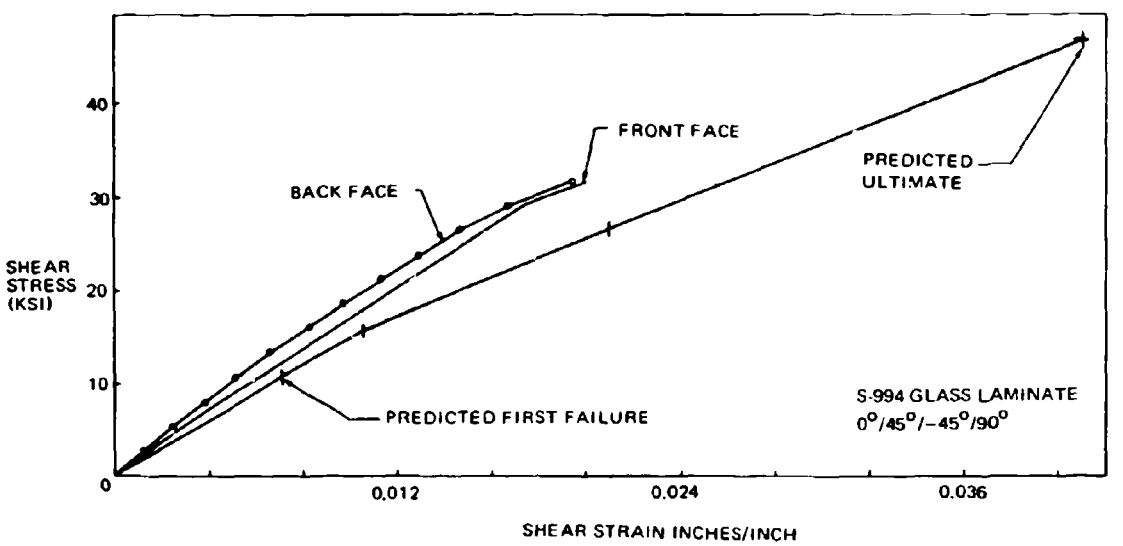
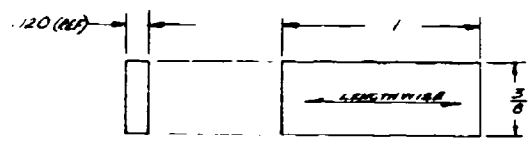
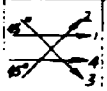
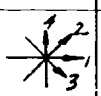


FIGURE 68. EDGEWISE SHEAR STRESS-STRAIN DIAGRAM FOR SPECIMEN Z3824843-505, NO. 3



DASH NO.	FIBER MAT'L	FIBER PATTERN LENGTH-WISE	NOMINAL PATTERN THICKNESS	NO. OF PATTERN REPETITIONS	NOMINAL SPECIMEN THICKNESS
-1	BORON SPEC MMS200A		0.020	6	0.120
-501	S-994 HTS GLASS	SAME AS -1	0.040	3	0.120
-503	BORON SPEC MMS200A		0.020	6	0.120
-505	S-994 HTS GLASS	SAME AS -503	0.040	3	0.120
-507	IDENTICAL TO -1 EXCEPT FOR ADDITION OF SILICON CARBIDE WHISKERS AT APPROXIMATELY 2% OF RESIN WEIGHT				0.120
-509	IDENTICAL TO -1 EXCEPT FOR ADDITION OF SILICON CARBIDE WHISKERS AT APPROXIMATELY 1% OF RESIN WEIGHT				0.120
-511	IDENTICAL TO -507 EXCEPT USING ALUMINUM OXIDE/ALUMINUM NITRIDE WHISKER MIXTURE				0.120

PART OR IDENTIFYING NO.

DASH NUMBERS OF THIS DRAWING
ODD DASH NUMBERS SHOWN
EVEN DASH NUMBERS OPPOSITE

QUANTITY REQUIRED PER NOTED ASSY

FINISH

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES.
TOLERANCES
FRACTIONS ± 1/32
DECIMALS ± .05
ANGLES ± 1/2°

MATL
WT CHK
STR CHK
CHECK
PR ENGR
DES ENGR
GR ENGR
PREP BY

SEE ENGINEERING RECORDS FOR USAGE DATA

FIRST RELEASE OF PRINTS
ORIGINAL DATE OF DRAWING MAY 29 1967

DESIGN
CUSTY

DRAWING Z4824816. SI

A

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

GEN NOTES : UNLESS OTHERWISE NOTED
1. SPECIMEN FABRICATION & PROCESSING METHODS TO BE PER DPS 1.463 - 4824B16
2. USE TABLE BELOW FOR CONFIGURATION INFO
3. IDENTIFY PER DPS 3.02
4. FIRST ISSUE RELEASE REQ'MNTS : 3 EA REQ OF -1 THRU -511

PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	STOCK SIZE	MATERIAL DESCRIPTION	MATERIAL SPECIFICATION	FIND NO.	ZONE

LIST OF MATERIALS

DASH NUMBERS OF THIS DRAWING USE DASH NUMBERS SHOWN EVEN DASH NUMBERS OPPOSITE

QUANTITY REQUIRED PER NOTED ASSY

FINISH

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES.
TOLERANCES
FRACTIONS ± 1/32
DECIMALS ± .015
ANGLES ± 1/2°

MATL		
WT CHK		
STR CHK		
CHECK		
PR ENGR	C. COMMAN	5/29/67
DES ENGR		
GR ENGR		
PREP BY	JAMAR	5-29-67

DOUGLAS AIRCRAFT COMPANY, INC LONG BEACH, CALIFORNIA

SPECIMEN - FIBROUS COMPOSITE HORIZONTAL SHEAR FLEXURE

ERING RECORDS FOR USAGE DATA

FIRST RELEASE OF PRINTS
ORIGINAL DATE OF DRAWING MAY 9 1967

DESIGN ACTIVITY APPROVAL
CUSTOMER APPROVAL

CODE IDENT NO. 88277 | SIZE C | Z4824816

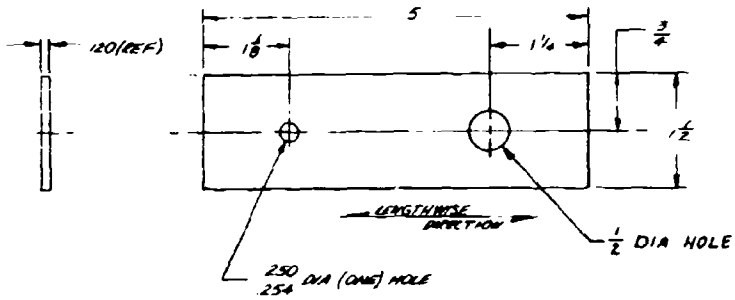
SCALE 2/1 | SHEET 1 OF 1

DRAWING Z4824816. SPECIMEN – FIBROUS COMPOSITE HORIZONTAL SHEAR FLEXURE

B

TABLE I
INTERLAMINAR SHEAR TEST RESULTS

CONFIGURATION	SPECIMEN MATERIALS	GAGE (IN.)	WIDTH (IN.)	AREA A, (SQ IN.)	FAILURE LOAD P, (LB)	INTERLAMINAR SHEAR STRENGTH = 3P/4A (PSI)
–1	BORON/NARMCO 5505	0.1203	0.4248	0.0511	715	10,480
		0.1194	0.4166	0.0496	657	9,940
		0.1158	0.4323	0.0501	683	10,200
–501	S-994 GLASS/NARMCO 5505	0.1364	0.3625	0.0494	790	12,000
		0.1283	0.3720	0.0477	795	12,500
		0.1384	0.3690	0.0511	845	12,400
–503	BORON/NARMCO 5505	0.1179	0.3988	0.0470	488	7,780
		0.1280	0.3950	0.0477	518	8,150
		0.1217	0.3906	0.0476	670	9,000
–505	S-994 GLASS/NARMCO 5505	0.1370	0.4007	0.0549	501	6,850
		0.1373	0.3648	0.0501	526	7,875
		0.1278	0.3900	0.0498	519	7,805
–507	BORON/NARMCO 5505	0.1152	0.3422	0.0394	705	13,425
	SiC-Al_2O_3 WHISKERS AT 2%	0.1201	0.3620	0.0435	712	12,250
	OF RESIN WEIGHT	0.1189	0.3651	0.0434	721	12,450
–509	BORON/NARMCO 5505	0.1181	0.3509	0.0414	680	12,300
	SiC-Al_2O_3 WHISKERS AT 1%	0.1173	0.3548	0.0416	669	12,040
	OF RESIN WEIGHT	0.1162	0.3532	0.0410	671	12,250
–511	BORON/NARMCO 5505	0.1190	0.3689	0.0439	629	10,720
	AlN-Al_2O_3 WHISKERS AT 2%	0.1242	0.3681	0.0457	661	10,830
	OF RESIN WEIGHT	0.1233	0.3678	0.0453	640	10,600



DASH NO.	FIBER MAT'L	FIBER PATTERN LENGTH-WISE	NOMINAL PATTERN THICKNESS	NO. OF PATTERN REPETITIONS	NOMINAL SPECIMEN THICKNESS
-1	BORON SPEC AMS2004A		0.020	6	0.120
-501	S-994 NTS GLASS	SAME AS -1	0.040	3	0.120
-503	BORON SPEC AMS 2004A		0.020	6	0.120
-505	S-994 NTS GLASS	SAME AS -503	0.040	3	0.120
-507	IDENTICAL TO -1 EXCEPT FOR ADDITION OF SILICON CARBIDE WHISKERS AT APPROXIMATELY 2% OF RESIN WEIGHT				0.120
-509	IDENTICAL TO -1 EXCEPT FOR ADDITION OF SILICON CARBIDE WHISKERS AT APPROXIMATELY 1% OF RESIN WEIGHT				0.120
-511	IDENTICAL TO -507 EXCEPT USING ALUMINUM OXIDE/ALUMINUM NITRIDE WHISKER MIXTURE				0.120

H

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

GEN NOTES: UNLESS OTHERWISE NOTED
1. SPECIMEN FABRICATION & PROCESSING METHODS TO BE PER DRS 1463-3824815
2. USE TABLE BELOW FOR CONFIGURATION INFO
3. IDENTIFY PER DRS 3.02
4. FIRST ISSUE RELEASE REQMTS:
   3 EA REQ OF -1 THRU -511

PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	STOCK SIZE	MATERIAL DESCRIPTION	MATERIAL SPECIFICATION	FINISH SPEC.	NOTE

LIST OF MATERIALS

QUALITY REQUIRED PER NOTED ASSY

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES.
TOLERANCES
FRACTIONS ± 1/32
DECIMALS ± .03
ANGLES ± 1/2°

MATL
HT CHK
ERR CHK
CHECK
PR ERR
DES ENGR
QR ERR
PREP BY

DOUGLAS AIRCRAFT COMPANY, INC. LONG BEACH, CALIFORNIA

SPECIMEN - FIBROUS COMPOSITE, PIN BEARING

SEE ENGINEERING RECORDS FOR USAGE DATA

PROJ RELEASE OF FINISH DRAWING

DESIGN ACTIVITY APPROVAL

CUSTOMER APPROVAL

DATE OF RELEASE

CODE IDENT NO. 88277 | SIZE D | Z3824815

SCALE 1/1 | SHEET 1 OF 1

DRAWING Z3824815. SPECIMEN – FIBROUS COMPOSITE PIN-BEARING

B

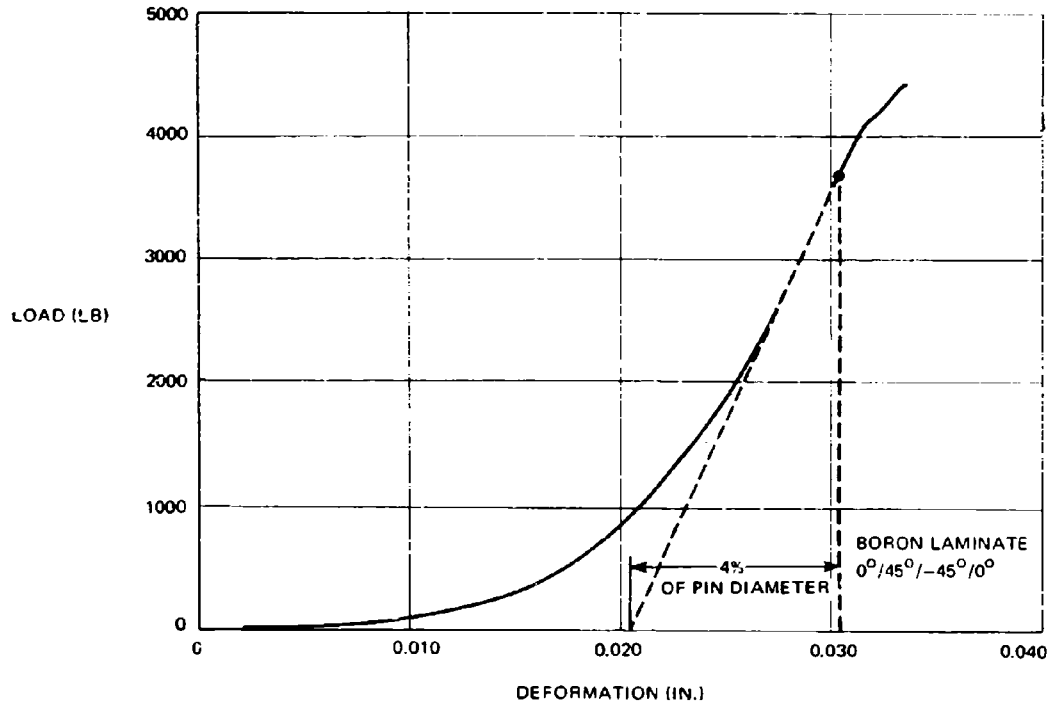


FIGURE 69. PIN-BEARING LOAD-DEFORMATION DIAGRAM FOR SPECIMEN Z3824815-1, NO. 1

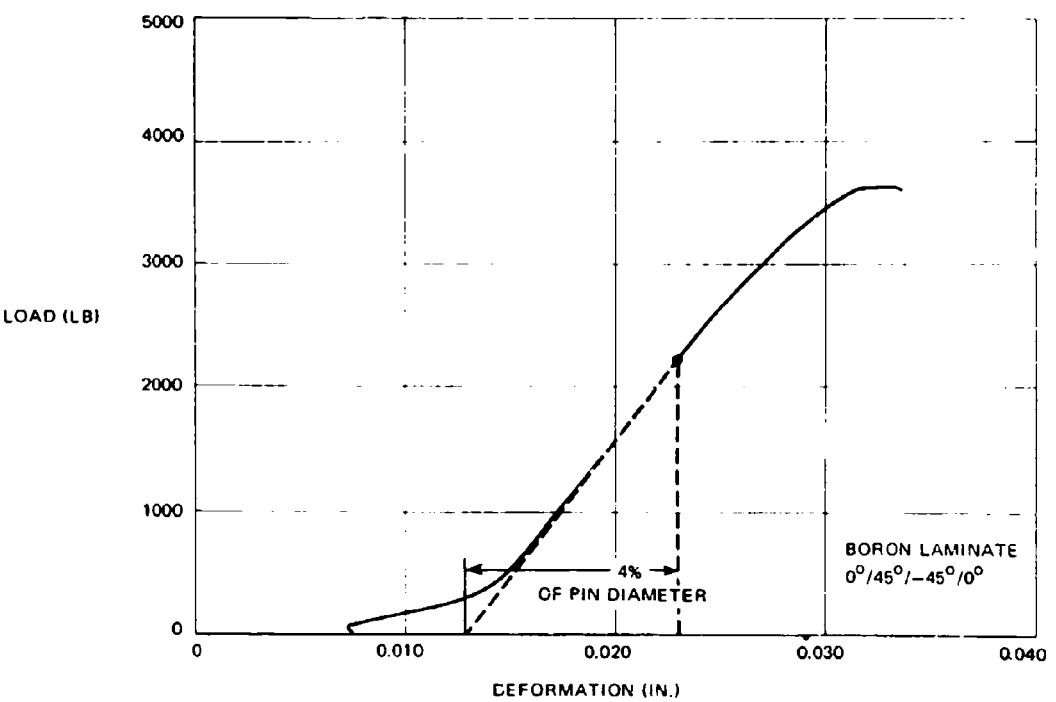


FIGURE 70. PIN-BEARING LOAD-DEFORMATION DIAGRAM FOR SPECIMEN Z3824815-1, NO. 2

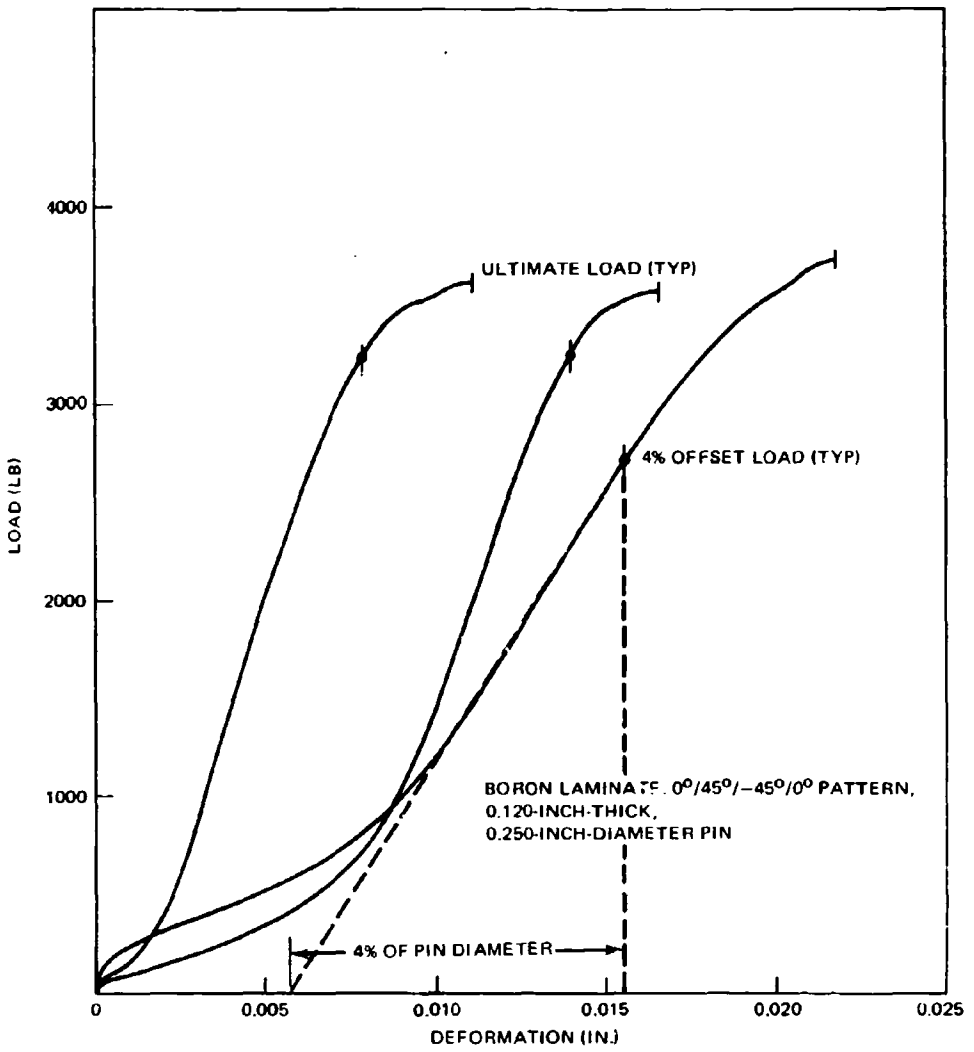


FIGURE 71. PIN-BEARING LOAD-DEFORMATION DIAGRAM FOR SPECIMEN Z3824815-1, NOS. 3, 4, AND 5

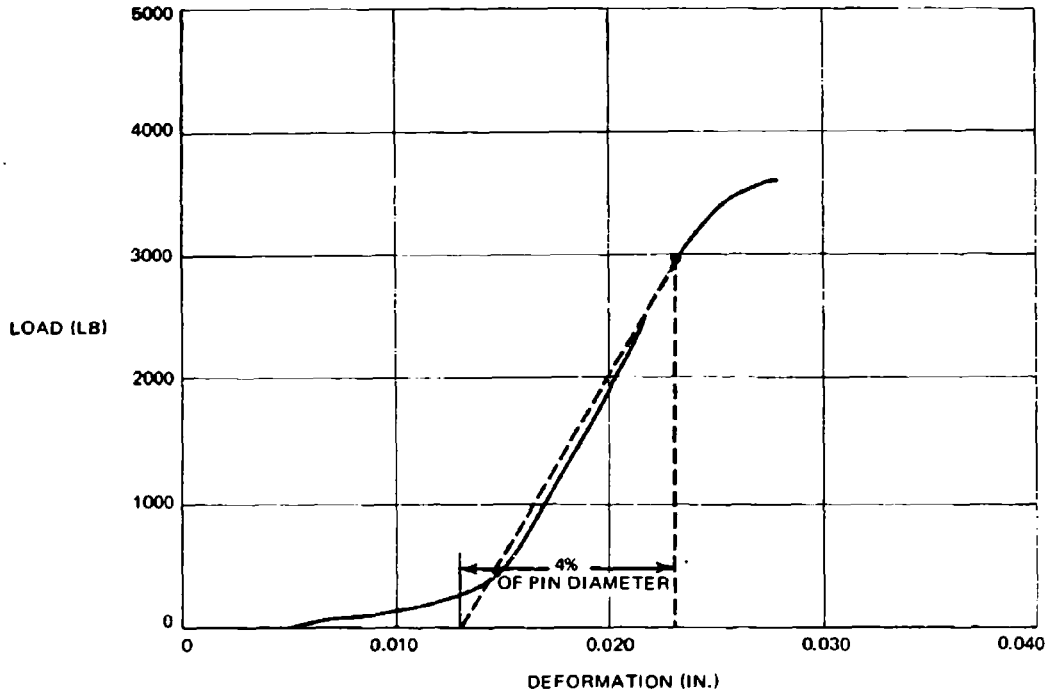


FIGURE 72. PIN-BEARING LOAD-DEFORMATION DIAGRAM FOR SPECIMEN Z3824815-503, NO. 1

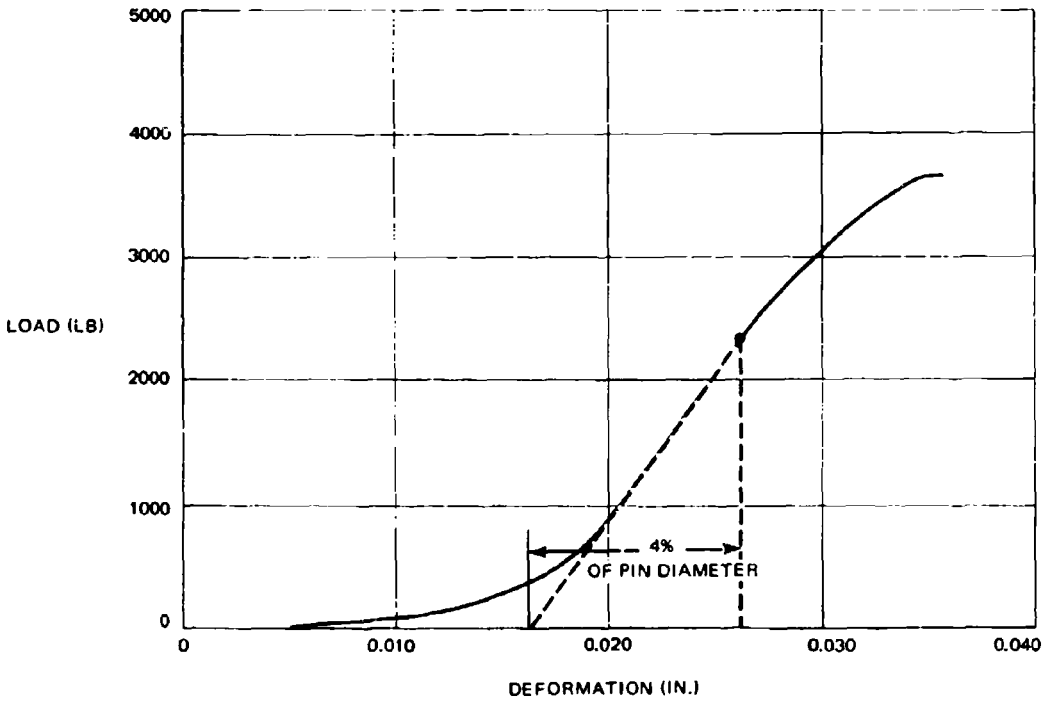


FIGURE 73. PIN-BEARING LOAD-DEFORMATION DIAGRAM FOR SPECIMEN Z3824815-503, NO. 2

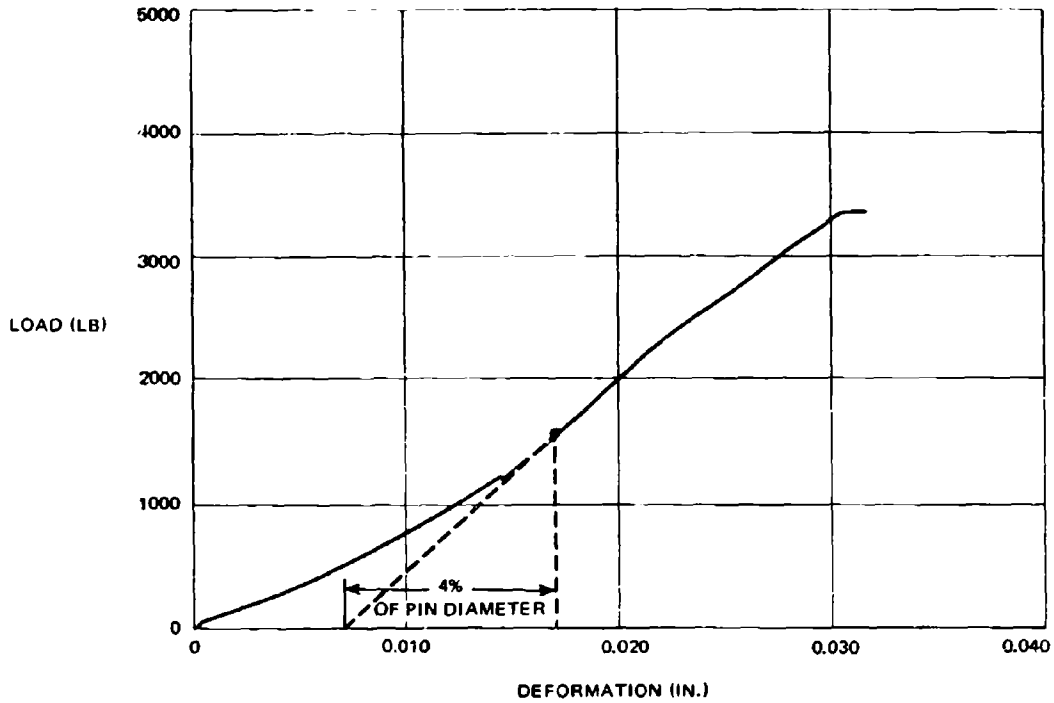


FIGURE 74. PIN-BEARING LOAD-DEFORMATION DIAGRAM FOR SPECIMEN Z3824815-503, NO. 3

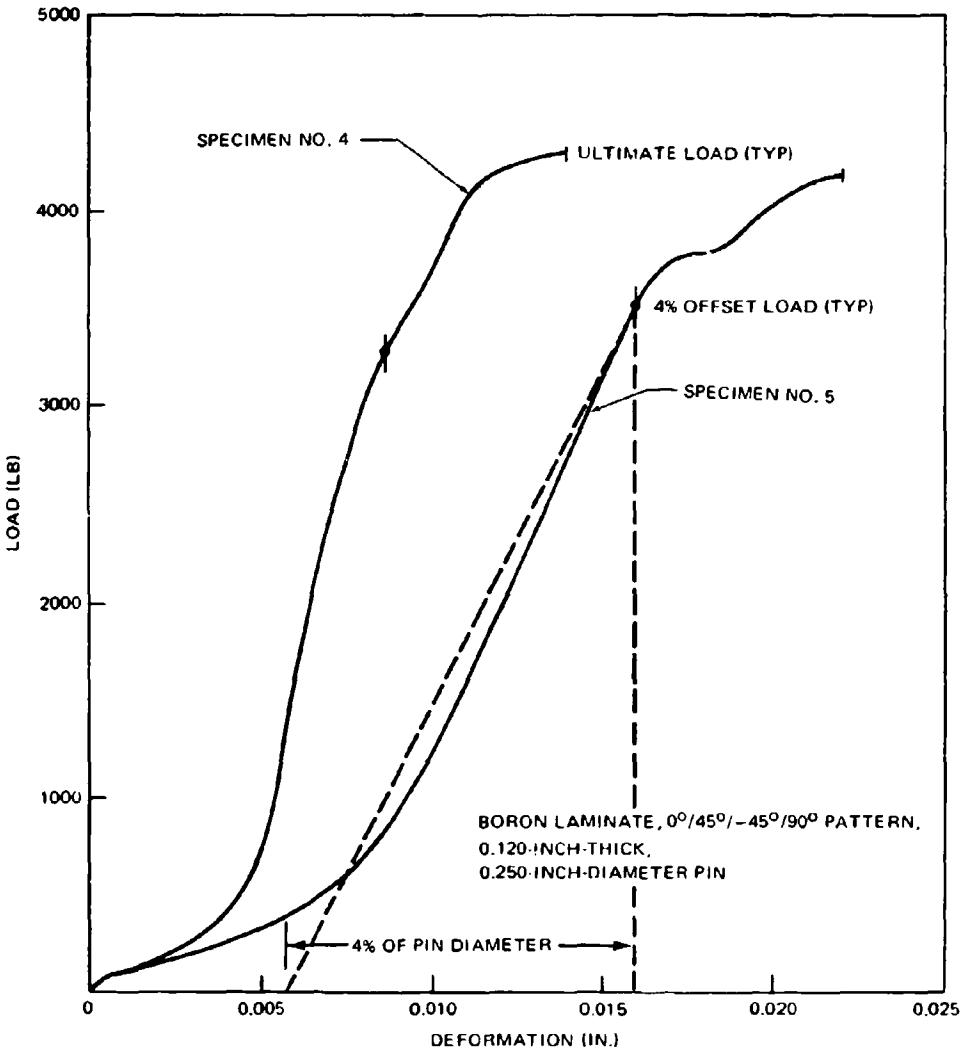


FIGURE 75. PIN-BEARING LOAD-DEFORMATION DIAGRAM FOR SPECIMEN Z3824815-503, NOS. 4 AND 5

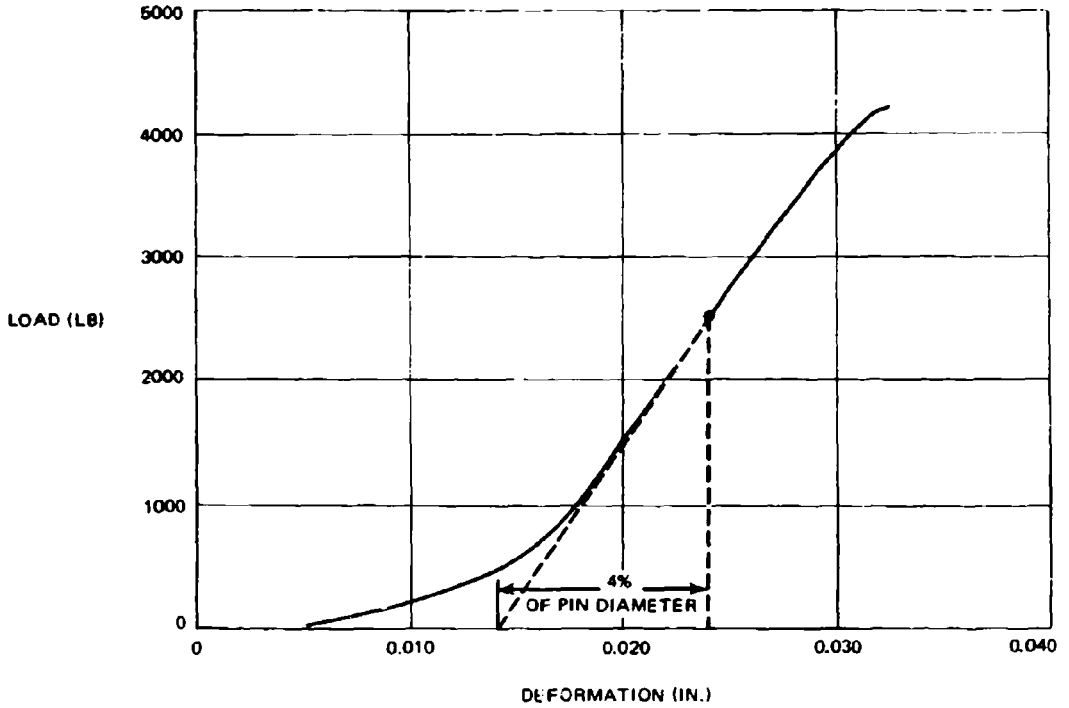


FIGURE 76. PIN-BEARING LOAD-DEFORMATION DIAGRAM FOR SPECIMEN Z3824815-511, NO. 1

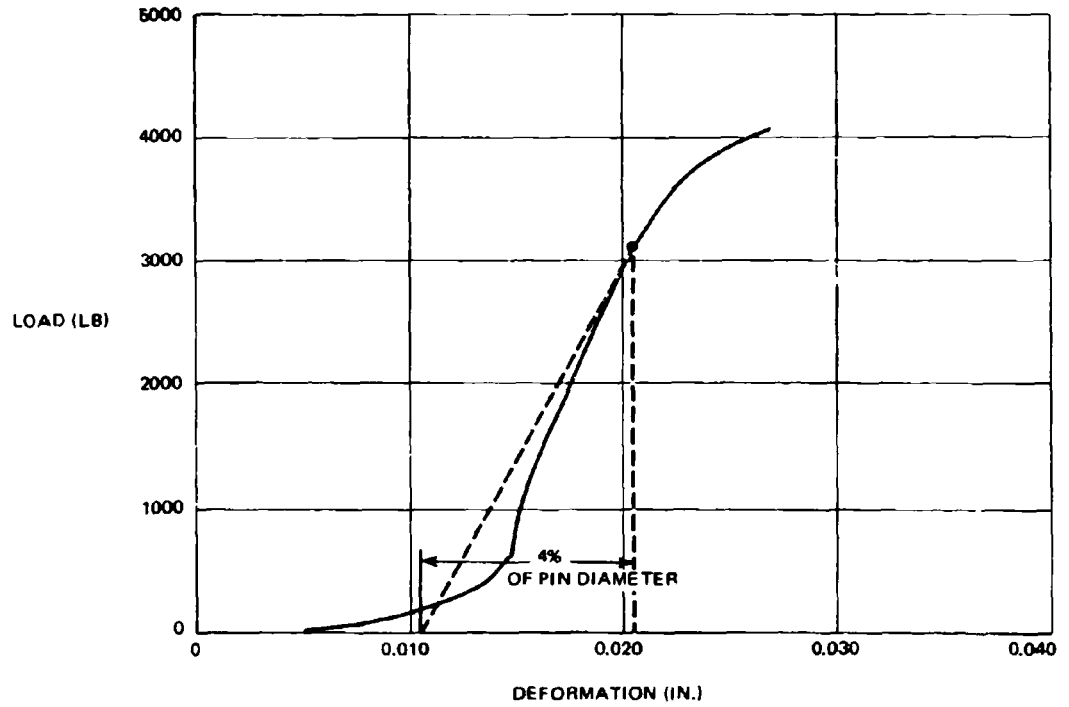


FIGURE 77. PIN-BEARING LOAD-DEFORMATION DIAGRAM FOR SPECIMEN Z3824815-511, NO. 2

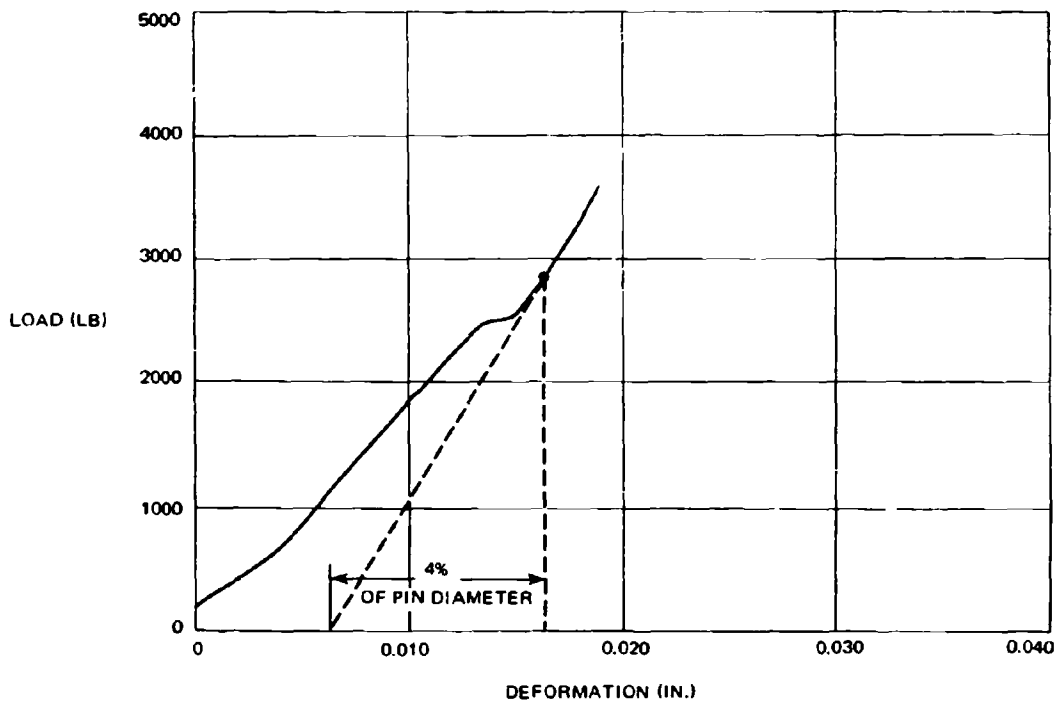


FIGURE 78. PIN-BEARING LOAD-DEFORMATION DIAGRAM FOR SPECIMEN Z3824815-511, NO. 3

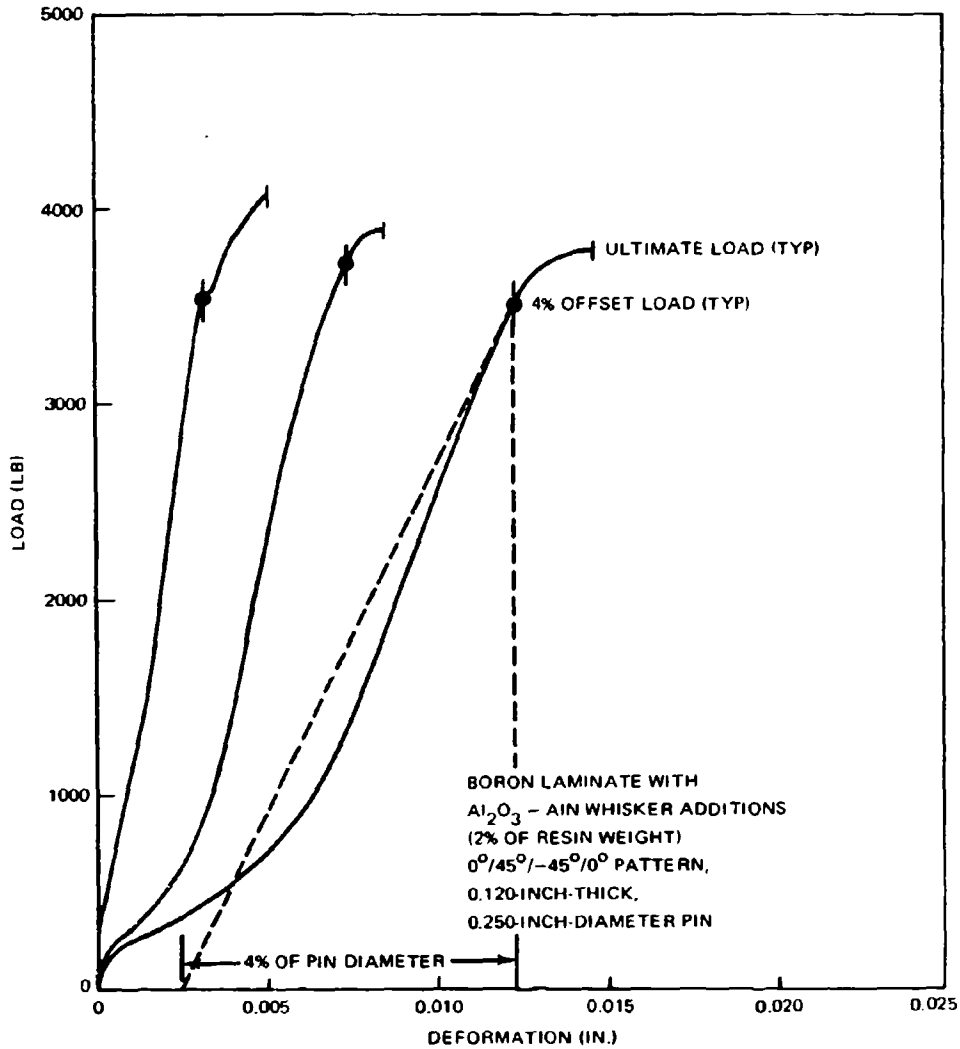


FIGURE 79. PIN-BEARING LOAD-DEFORMATION DIAGRAM FOR SPECIMEN Z3824815-511, NOS. 4, 5, AND 6

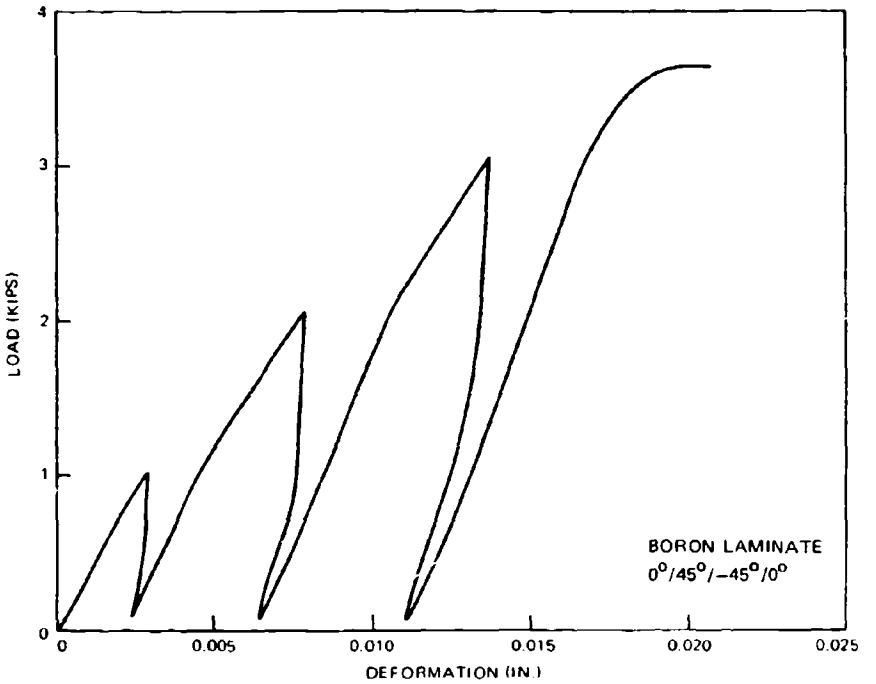


FIGURE 80. PIN-BEARING LOAD-DEFORMATION DIAGRAM FOR SPECIMEN Z3824315-1, NO. 1, INCREMENTALLY LOADED

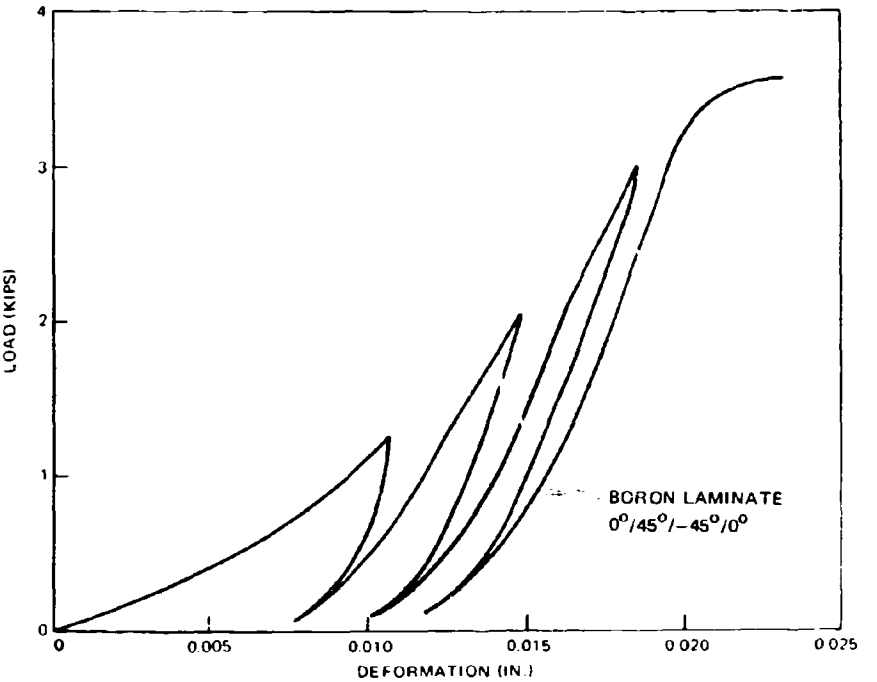


FIGURE 81. PIN-BEARING LOAD-DEFORMATION DIAGRAM FOR SPECIMEN Z3824815-1, NO. 2, INCREMENTALLY LOADED

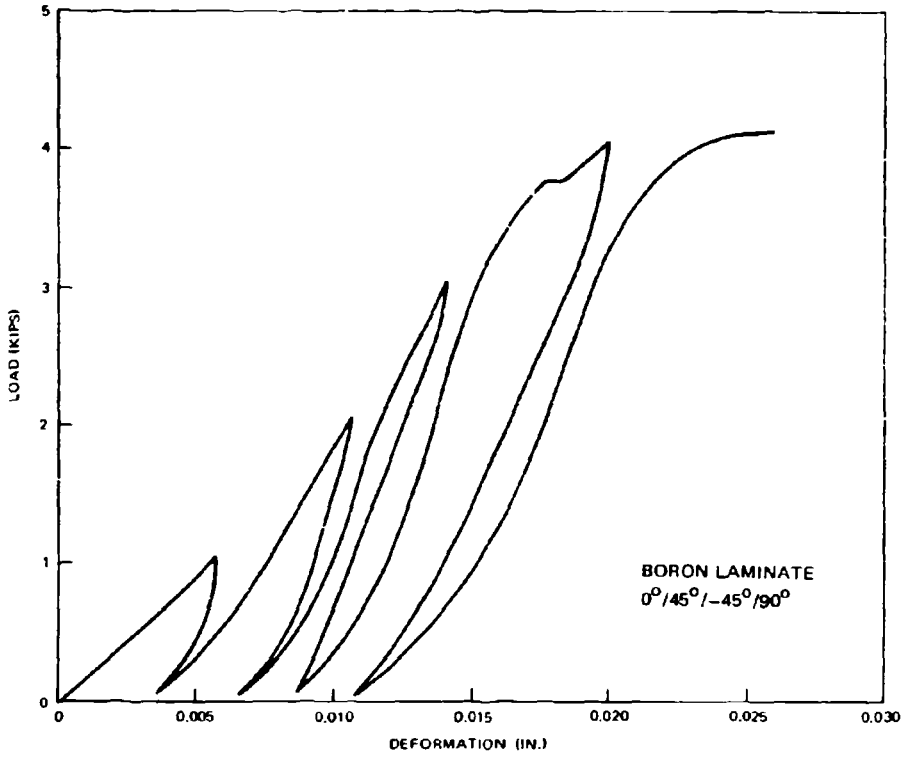


FIGURE 82. PIN-BEARING LOAD-DEFORMATION DIAGRAM FOR SPECIMEN Z3824815-503, NO. 1, INCREMENTALLY LOADED

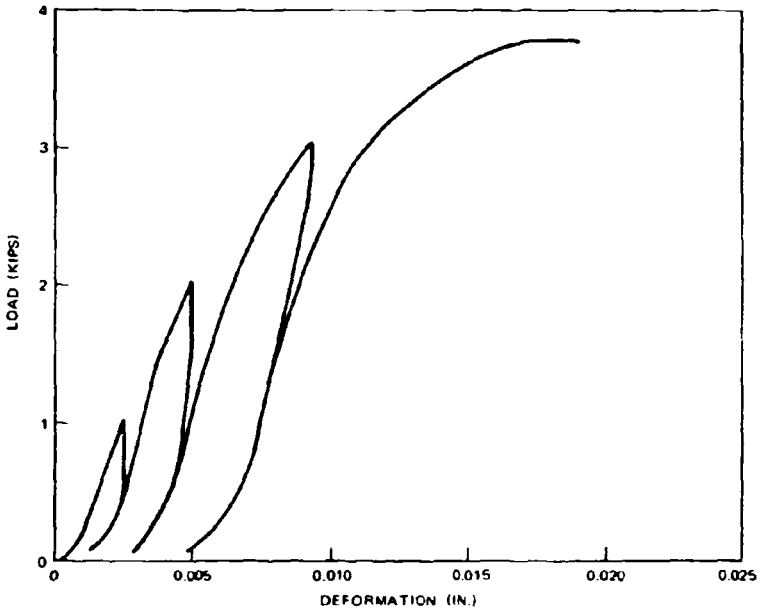


FIGURE 83. PIN-BEARING LOAD-DEFORMATION DIAGRAM FOR SPECIMEN Z3824815-503, NO. 2, INCREMENTALLY LOADED

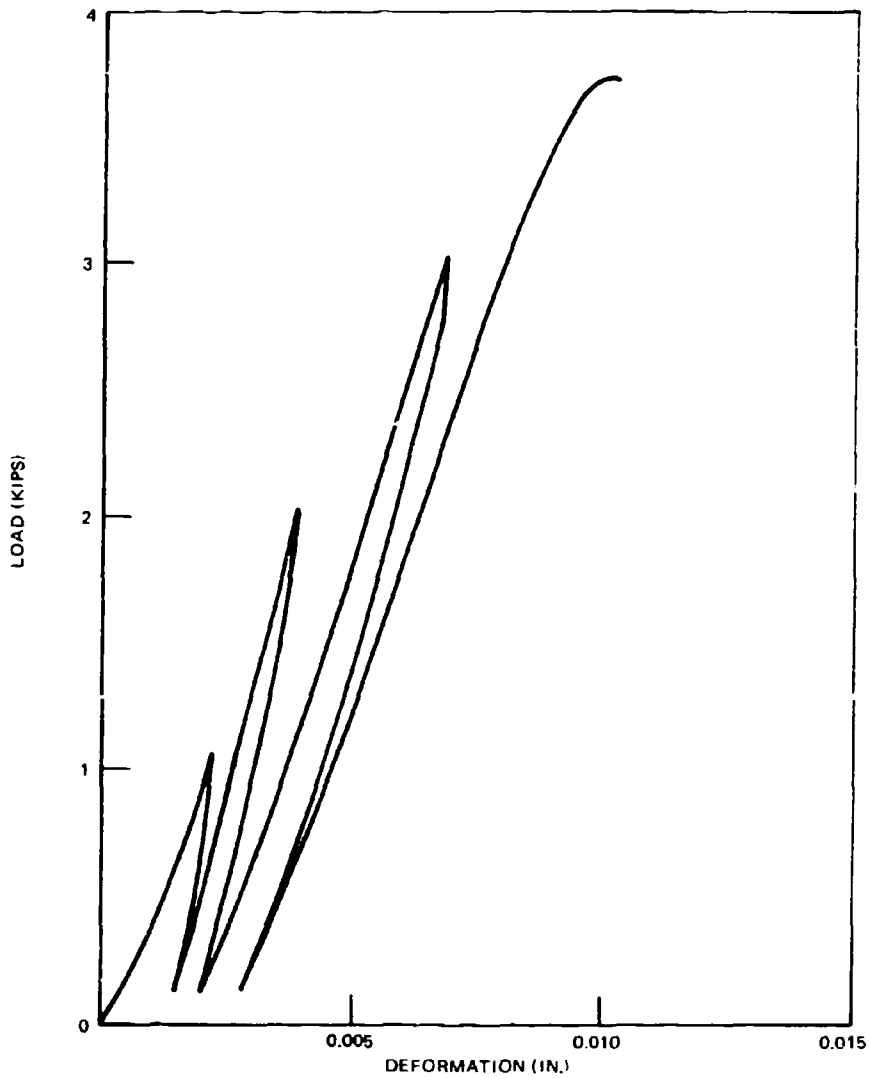
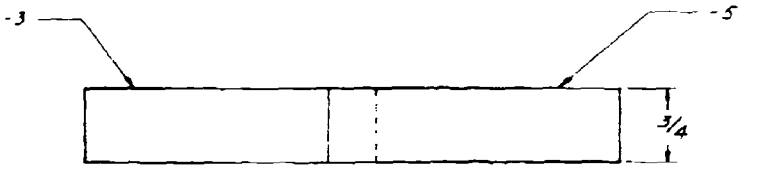
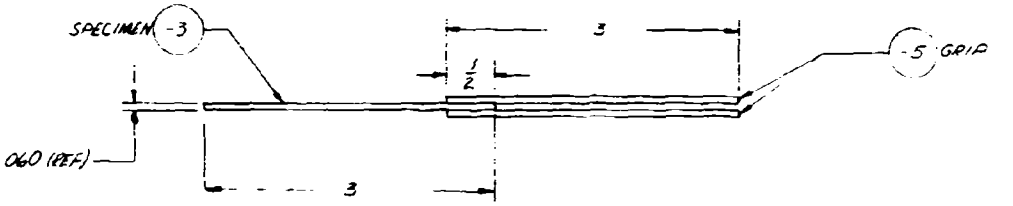


FIGURE 84. PIN-BEARING LOAD-DEFORMATION DIAGRAM FOR SPECIMEN Z382A815-503, NUMBER 3, INCREMENTALLY LOADED.





CONFIG	EPOXY	MANUFACTURER
-1	AF137 (NOVALAC)	3M COMPANY
-501	252/250 ECURE)	NARMCO
-503	AF110B (NITRILE)	3M COMPANY
-505	HT424 (PHENOLIC)	BLOOMING DALE RUBBER CO
-507	951 (NYLON)	SHELL
-509	109 (COLD SET)	UEFKOWELD

2	2	2	2	2	2	-5
1	1	1	1	1	1	-3
-509	-507	-505	-503	-501	-1	PART IDENTIFY

QUANTITY REQUIRED PER NOTED ASSY

FINISH

UNLESS OTHE SPECIFIED

DIMENSIONS IN INCHES.

TOLERANCE

FRACTIONS ± 1

DECIMALS ± .0

ANGLES ± 1/2°

SEE ENGINEERING RECORDS FOR USAGE DATA

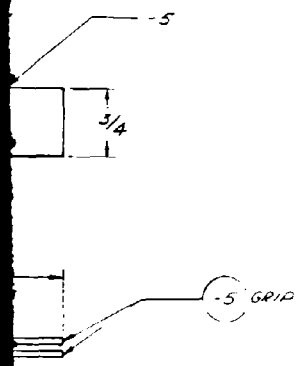
FIRST RELEASE OF PRINTS

ORIGINAL DATE OF DRAWING JUN 2 6 1

DRIG SYST. | REL CODE

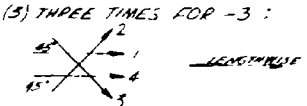
A

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



GEN NOTES : UNLESS OTHERWISE NOTED

1 USE THE FOLLOWING LAMINATION PATTERN REPEATED (3) THREE TIMES FOR -3 :



2 IDENTIFY PER DPS 3.02

3 SPECIMEN FAB & PROCESSING METHODS PER DPS 1463-4824E24

4 FIRST ISSUE RELEASE REQMNTS : SEA REQ OF -1 THRU -509 INCL

5 BOND -3 TO -5 GRIPS WITH NYLON FOR [illegible]

PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	STOCK SIZE	MATERIAL DESCRIPTION	MATERIAL SPECIFICATION	FIND NO.	ZONE
-5	GRIP		.063 X 3 X 3/4	AL SHT CLAD 7075-T6	QQ-A-250/13 TEMP T6		
-3	SPECIMEN		SEE G/N	#1	BORON FMS 2001A		

LIST OF MATERIALS

QUANTITY REQUIRED PER NOTED ASSY						
-509	-507	-505	-503	-501	-1	DASH NUMBERS OF THIS DRAWING
2	2	2	2	2	2	ODD DASH NUMBERS SHOWN
1	1	1	1	1	1	EVEN DASH NUMBERS OPPOSITE

FINISH

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES.
TOLERANCES
FRACTIONS ± 1/32
DECIMALS ± .015
ANGLES ± 1/2°

MATL		
WT CHK		
STR CHK		
CHECK		
PR ENGR	[illegible]	6-21-67
DES ENGR		
QR ENGR		
PREP BY	DVORAK	6-16-67

DOUGLAS AIRCRAFT COMPANY, INC LONG BEACH, CALIFORNIA

SPECIMEN ASSY - ADHESIVE DOUBLE LAP SHEAR

EERING RECORDS FOR USAGE DATA

FIRST RELEASE OF PRINTS
ORIGINAL DATE OF DRAWING JUN 16 1967

DESIGN ACTIVITY APPROVAL
CUSTOMER APPROVAL

CODE IDENT NO. 88277 | SIZE C | Z4824824

SCALE 1/1 | SHEET 1 OF 1

DRAWING Z4824824. SPECIMEN ASSEMBLY – ADHESIVE DOUBLE LAP SHEAR

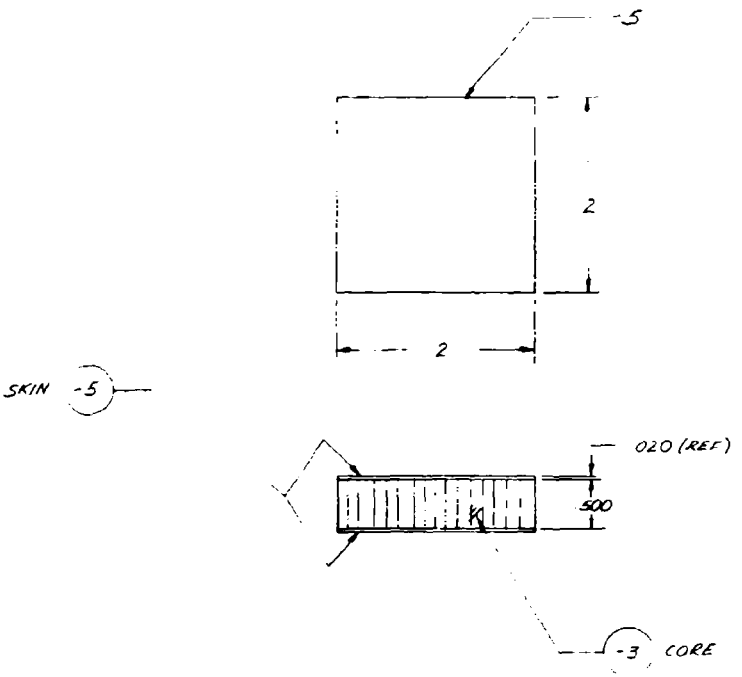
TABLE II
ADHESIVE DOUBLE LAP SHEAR TEST RESULTS
(Specimen No. Z 4824824)

Dash No.	Specimen No.	Adhesive	Bond Line Data			Ultimate Load (Lb)	Adhesive Average Shear Stress (Psi)	Type of Failure
			Width (In)	Overlap (In)	Area (Sq In.)			
-1	1	AF 130	0.769	0.570	0.877	880	1,004	Failure was 100% between the boron fibers and resin in first ply of laminate, both sides of specimen.
	2		0.758	0.490	0.743	925	1,245	
	3		0.764	0.550	0.840	960	1,142	
	4		0.784	0.570	0.894	860	962	
	5		0.786	0.530	0.833	1,060	1,272	
-501	1	Narmco 252	0.778	0.510	0.794	3,920	4,940	Glass scrim side – 50% adhesion tc laminate surface area 50% laminate resin to boron fibers Opposite side – 100% adhesive to laminate.
	2		0.781	0.500	0.781	3,925	5,026	
	3		0.771	0.470	0.725	2,925	4,036	
	4		0.760	0.460	0.699	3,925	5,614	
	5		0.775	0.530	0.822	3,795	4,620	
-503	1	AF 1108	0.770	0.500	0.770	3,650	4,740	Glass scrim side – 75% cohesion, 25% resin to boron Opposite side – 75% cohesive, 25% adhesive to laminate.
	2		0.765	0.510	0.780	3,475	4,453	
	3		0.768	0.520	0.799	3,225	4,038	
	4		0.771	0.510	0.786	3,485	4,432	
	5		0.771	0.500	0.771	*3,380	(4,390)	
-505	1	Bloomingdale HT 424	0.788	0.500	0.788	1,075	1,364	Glass scrim side – 50% adhesive to laminate, 50% resin to boron, Opposite side – mainly between resin and boron fiber.
	2		0.782	0.540	0.845	1,725	2,043	
	3		0.760	0.540	0.821	875	1,066	
	4		0.759	0.520	0.789	1,040	1,317	
	5		0.767	0.560	0.859	1,435	1,670	
-507	1	Shell 951	0.769	0.470	0.723	4,175	5,775	Glass scrim side – 90% between laminate resin and boron. Opposite side – 50% cohesive, 50% adhesive to laminate.
	2		0.780	0.520	0.811	4,370	5,387	
	3		0.780	0.500	0.780	*4,075	(5,220)	
	4		0.770	0.500	0.770	4,590**	(5,950)	
	5		0.789	0.510	0.804	*4,370†	(5,450)	
-509	1	Lefkoweld 109	0.766	0.520	0.797	1,500	1,883	50% adhesive to laminate, 50% adhesive to aluminum.
	2		0.792	0.530	0.840	1,475	1,756	
	3		0.774	0.520	0.805	1,575	1,956	
	4		0.785	0.530	0.832	1,300	1,562	
	5		0.782	0.520	0.813	1,825	2,244	

*Failed in Grip.

**This specimen was tested with A1 alloy gripping tabs bonded to the composite. The specimen failed in tension though the basic section at a composite stress level of 98,000 psi.

†This specimen was salvaged with A1 alloy gripping tabs bonded to the composite and retested. Bond failed in shear at load of 2790 pounds during retest.



CONFIG	EPOXY	MANUFACTURER
-1	AF130 (NOVALAC)	3M COMPANY
-501	252 (250 F CURE)	NARMCO
-503	AF10B (NITRILE)	3M COMPANY
-505	HT424 (PHENOLIC)	BLOOMINGDALE RUBBER CO.
-507	951 (NYLON)	SHELL
-509	109 (COLD SET)	LEFKOWALL

2	2	2	2	2	2	-5
1	1	1	1	1	1	-3
-509	-507	-505	-503	-501	-1	PART OF IDENTIFYIN

QUANTITY REQUIRED PER NOTED ASSY

DASH NUMBERS O
ODD DASH NUMBE
EVEN DASH NUM

FINISH

UNLESS OTHERW SPECIFIED

DIMENSIONS AR IN INCHES.

TOLERANCES

FRACTIONS ± 1/

DECIMALS ± .015

ANGLES ± 1/2°

SEE ENGINEERING RECORDS FOR USAGE DATA

FIRST RELEASE OF PRINTS

ORIGINAL DATE OF DRAWING JUL 19

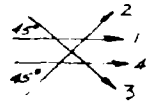
PROJ. ENGR. | MFG. CODE

A

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

GEN NOTES : UNLESS OTHERWISE NOTED

1. USE THE FOLLOWING LAMINATION PATTERN (ONE SEQUENCE ONLY) FOR -5 :



2. IDENTIFY PER DPS 3.02
3. SPECIMEN FAB & PROCESSING METHODS PER DPS 1.463-4824825
4. FIRST ISSUE RELEASE REQMNTS. SEA REQ'D OF -1 THRU -509 INCL
5. BOND -5 SKINS TO -3 CORE WITH NOTED ADHESIVES.

QUANTITY REQUIRED PER NOTED ASSY	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	STOCK SIZE	MATERIAL DESCRIPTION	MATERIAL SPECIFICATION	FIND NO.	ZONE
2	-5	SKIN	SEE	G/N #1		BORON FMS 200 1A		
1	-3	CORE		.500 x 2 x 2	AL HONEYCOMB 3/16 -5052-.004N	PURCHASE FROM HEXCEL PRODUCTS INC IN ARROW HIGHWOOD CORE		

LIST OF MATERIALS

DASH NUMBERS OF THIS DRAWING ODD DASH NUMBERS SHOWN EVEN DASH NUMBERS OPPOSITE

-509 -507 -505 -503 -501 -1

FINISH

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES.
TOLERANCES
FRACTIONS ± 1/32
DECIMALS ± .015
ANGLES ± 1/2°

MATL		
WT CHK		
STR CHK		
CHECK		
PR ENGR	[illegible]	[illegible]
DES ENGR		
GR ENGR		
PREP BY	DVORAK	8-19-67

DOUGLAS AIRCRAFT COMPANY, INC LONG BEACH, CALIFORNIA

SPECIMEN ASSY - ADHESIVE FLATWISE TENSION

RECORDS FOR USAGE DATA

FIRST RELEASE OF PRINTS

ORIGINAL DATE OF DRAWING JUL 19 1967

DESIGN ACTIVITY APPROVAL

CUSTOMER APPROVAL

CODE IDENT NO. 88277 | SIZE C | Z4824825

SCALE 1/1 | SHEET 1 OF 1

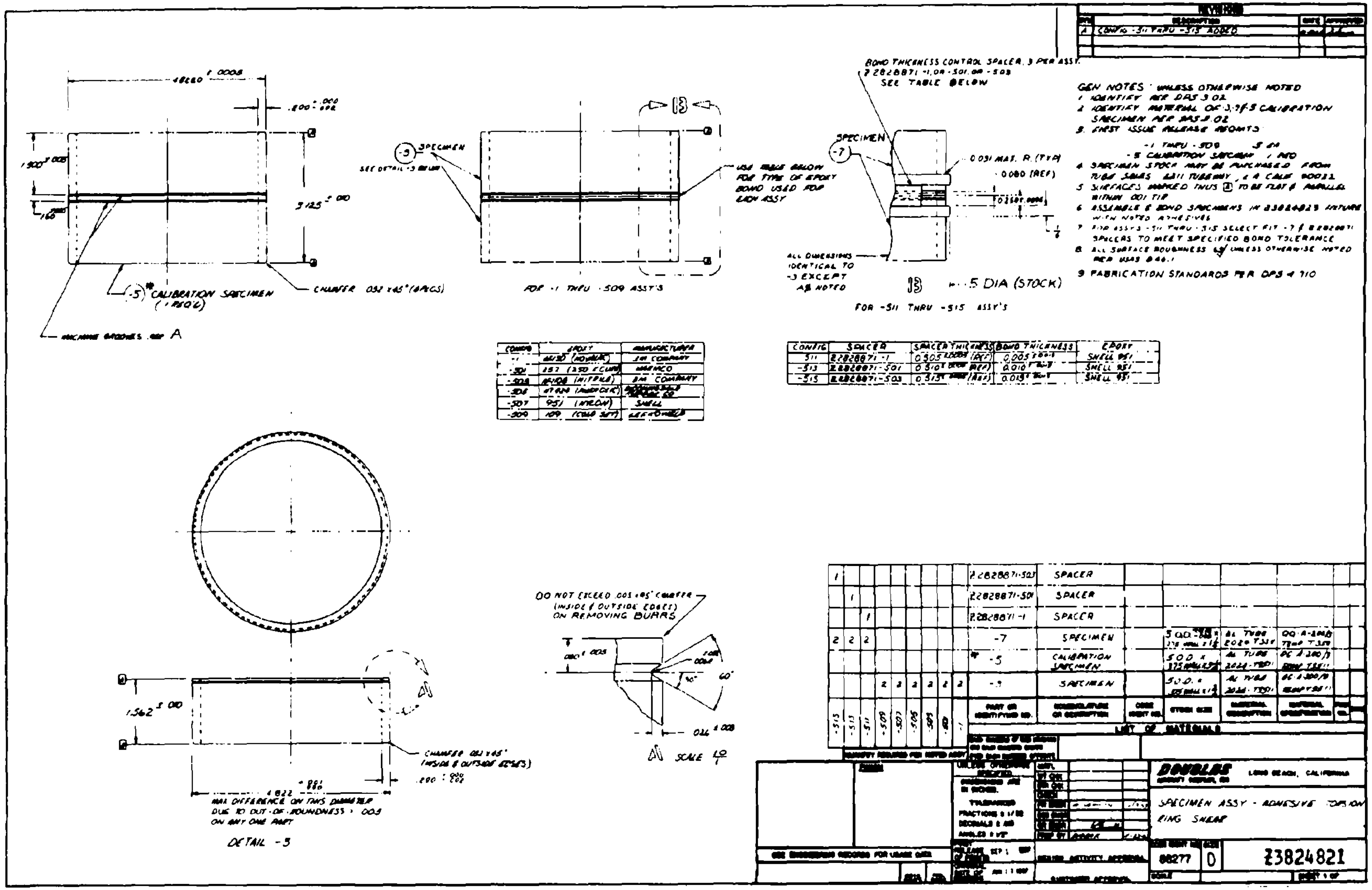
DRAWING Z4824825. SPECIMEN ASSEMBLY – ADHESIVE FLATWISE TENSION

TABLE III
ADHESIVE FLATWISE TENSION TEST RESULTS

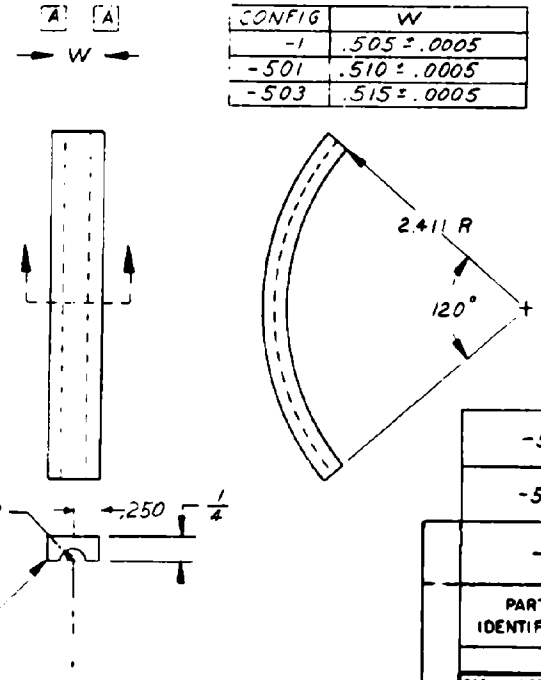
SPECIMEN NO. Z 4824825

ADHESIVE	ULTIMATE LOAD (LB)	ADHESIVE STRESS (PSI)	AVERAGE STRESS (PSI)	TYPE FAILURE
AF-130	2745	686	648	ALUMINUM HOLDING FIXTURE TO BORON SKIN
3-M	2790	698		
(–1)	2330	583		
	2495	624		
252	2990	748	753	ADHESIVE 80% CORE 20%
NARMCO	3005	751		CORE 100%
(–501)	2515	629*		BORON SKIN TO ALUMINUM BLOCK*
	2992	748		CORE 100%
	3060	765		CORE 100%
AF-1108	2970	743	747	CORE 100%
3-M	3065	766		CORE 50% BORON SKIN 50%
(–503)	3020	755		CORE 100%
	2890	723		CORE 100%
HT-424	1040	251	337	ADHESIVE TO BORON
BLOOMINGDALE	1530	382		ADHESIVE 50%
(–505)	1280	320		ADHESIVE TO BORON
	1585	398		ADHESIVE 20%
SHELL	2940	735	721	CORE 100%
951	2460	615*		BORON SKIN TO ALUMINUM BLOCK*
(–507)	2863	716		CORE 100%
	2755	689		CORE 100%
	2980	745		SKIN DELAMINATION
109	2245	561	492	BORON SKIN
LEFKOWELD	2717	679		BORON 50% CORE 50%
(–509)	2060	515		CORE 100%
	857	214		BORON SKIN

*NOT INCLUDED IN AVERAGE – FAILED AT SKIN-TO-TEST BLOCK INTERFACE.



DRAWING Z3824821. SPECIMEN ASSEMBLY – ADHESIVE TORSION RING SHEAR



CONFIG	W
-1	.505 ± .0005
-501	.510 ± .0005
-503	.515 ± .0005

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

GEN. NOTES: UNLESS OTHERWISE NOTED
1. FABRICATION STANDARDS PER DPS 4.710
2. SURFACES MARKED THUS [A] TO BE FLAT & PARALLEL TO SPECIFIED TOLERANCE
3. STOCK TUBING MAYBE PURCHASED FROM TUBE SALES, 2211 TUBEWAY, LA., CALIF. 90022
4. THREE SPACERS MAY BE MADE FROM ONE SECTION OF TUBING
5. ALL MACHINED SURFACES PER USAS B46.1.
6. IDENTIFY PARTS PER DPS 3.02
* 7. AL PLATE MAY BE USED AS SUBSTITUTE MATL 6061-0 QQ-A-250/11 TEMP O-HT SUBSTITUTE PART TO 6061-T651 PER DPS 7.0C.

PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	STOCK SIZE	MATERIAL DESCRIPTION	MATERIAL SPECIFICATION	FIND NO.	ZONE
-503	SPACER		5½ OD x .375 WALL x 1¾	*AL TUBE 6061-T6511	WW-T-700/6 TYPE I TEMP-T6511		
-501	SPACER		5½ OD x .375 WALL x 1¾	*AL TUBE 6061-T6511	WW-T-700/6 TYPE I TEMP-T6511		
-1	SPACER		5½ OD x .375 WALL x 1¾	*AL TUBE 6061-T6511	WW-T-700/6 TYPE I TEMP-T6511		

LIST OF MATERIALS

DASH NUMBERS OF THIS DRAWING
ODD DASH NUMBERS SHOWN
EVEN DASH NUMBERS OPPOSITE

QUANTITY REQUIRED PER NOTED ASSY

FINISH

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES.
TOLERANCES
FRACTIONS ± 1/32
DECIMALS ± .015
ANGLES ± 1/2°

MATL		
WT CHK		
STR CHK		
CHECK	Stone CA.	11-9-68
PR ENGR	A Leaman	8-12-68
DES ENGR		
GR ENGR		10-15-68
PREP BY	N W WRIGHT	8-19-68

DOUGLAS AIRCRAFT COMPANY, INC — LONG BEACH, CALIFORNIA

SPACER - ADHESIVE BOND LINE THICKNESS CONTROL

SEE ENGINEERING RECORDS FOR USAGE DATA

FIRST RELEASE OF PRINTS OCT 23 1968

ORIGINAL DATE OF DRAWING AUG 16 1968

ORIG SECT | REL CODE

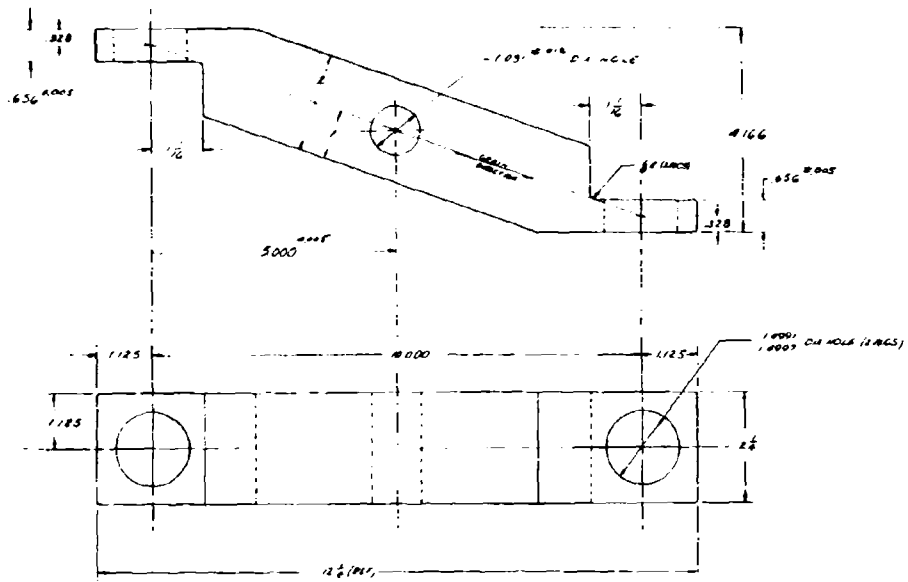
DESIGN ACTIVITY APPROVAL

CUSTOMER APPROVAL

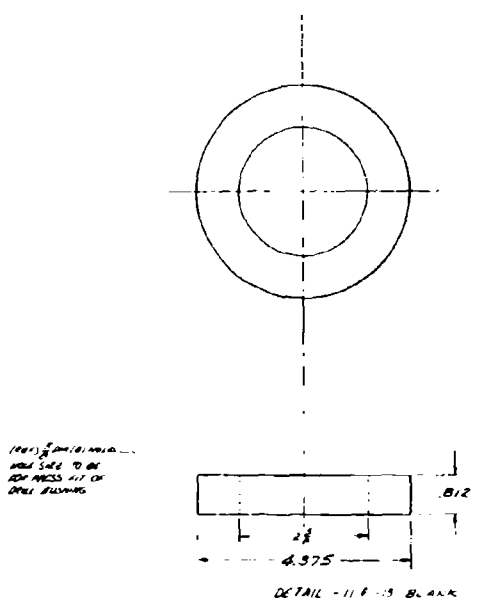
CODE IDENT NO.	SIZE	
88277	B	Z2828871

SCALE 1/1 — SHEET 1 OF

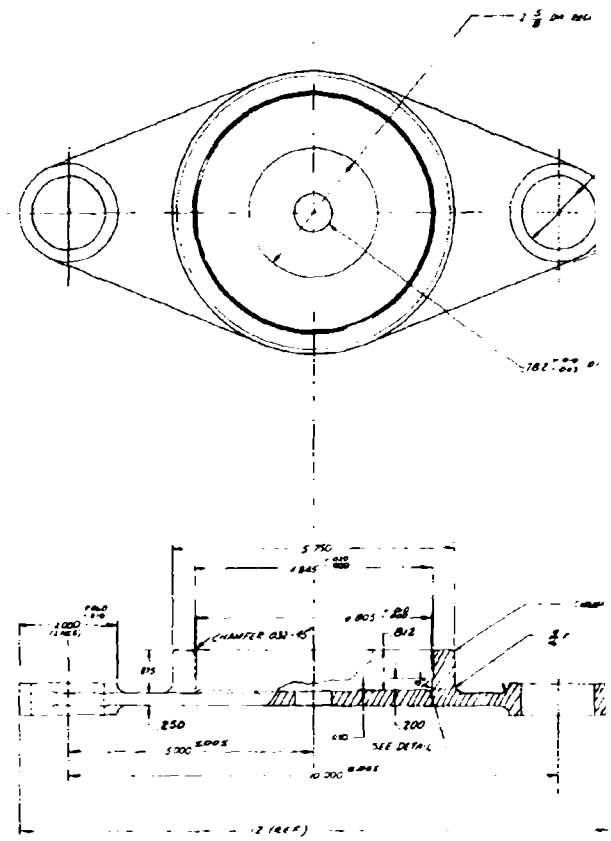
DRAWING Z2828871. SPACER – ADHESIVE BOND LINE THICKNESS CONTROL



DETAIL -3



DETAIL -11 & -13 BLANK

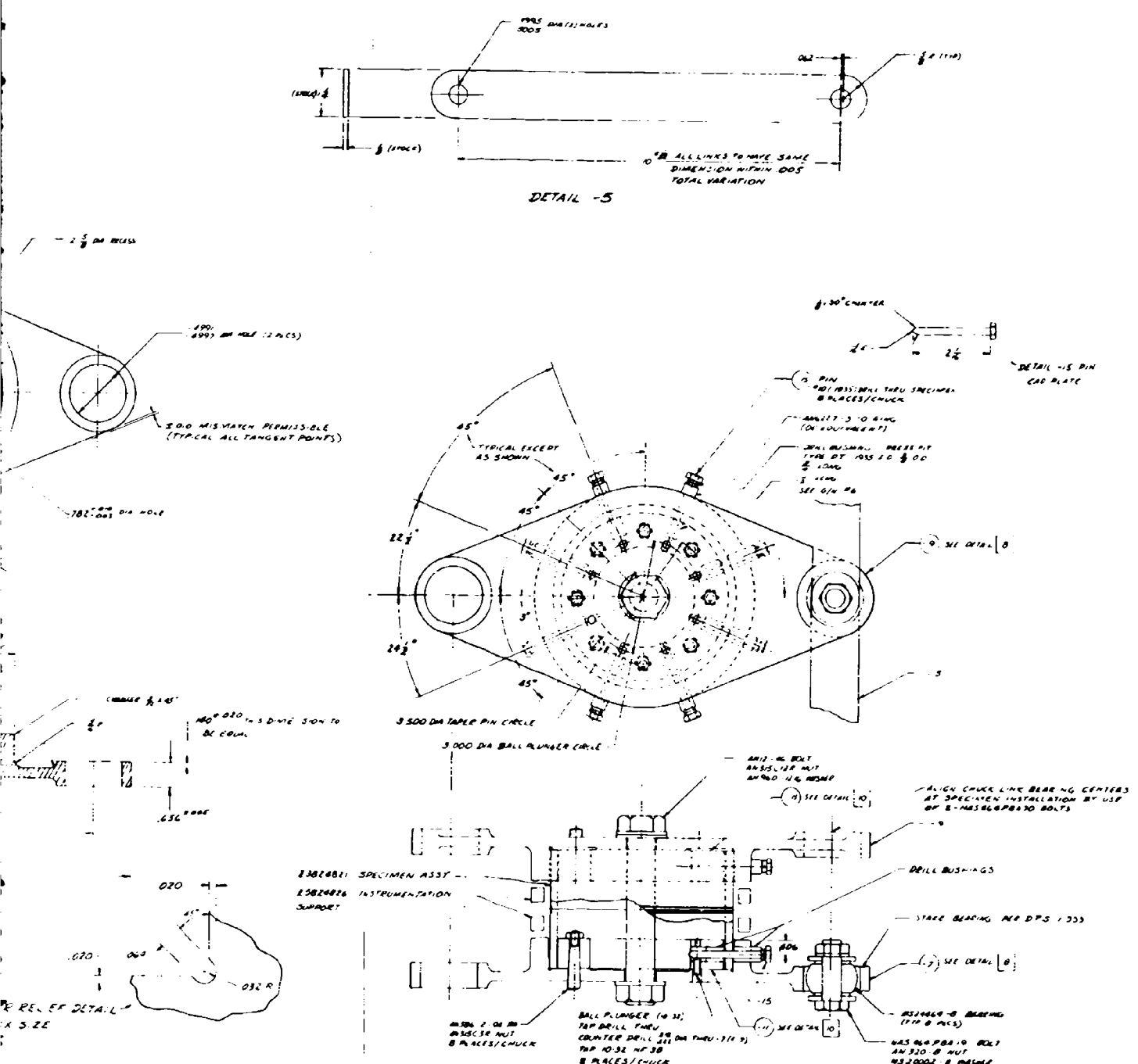


DETAIL -7 & -9
CHUCK BLANK

CORNER RELIEF DETAIL
10X SIZE

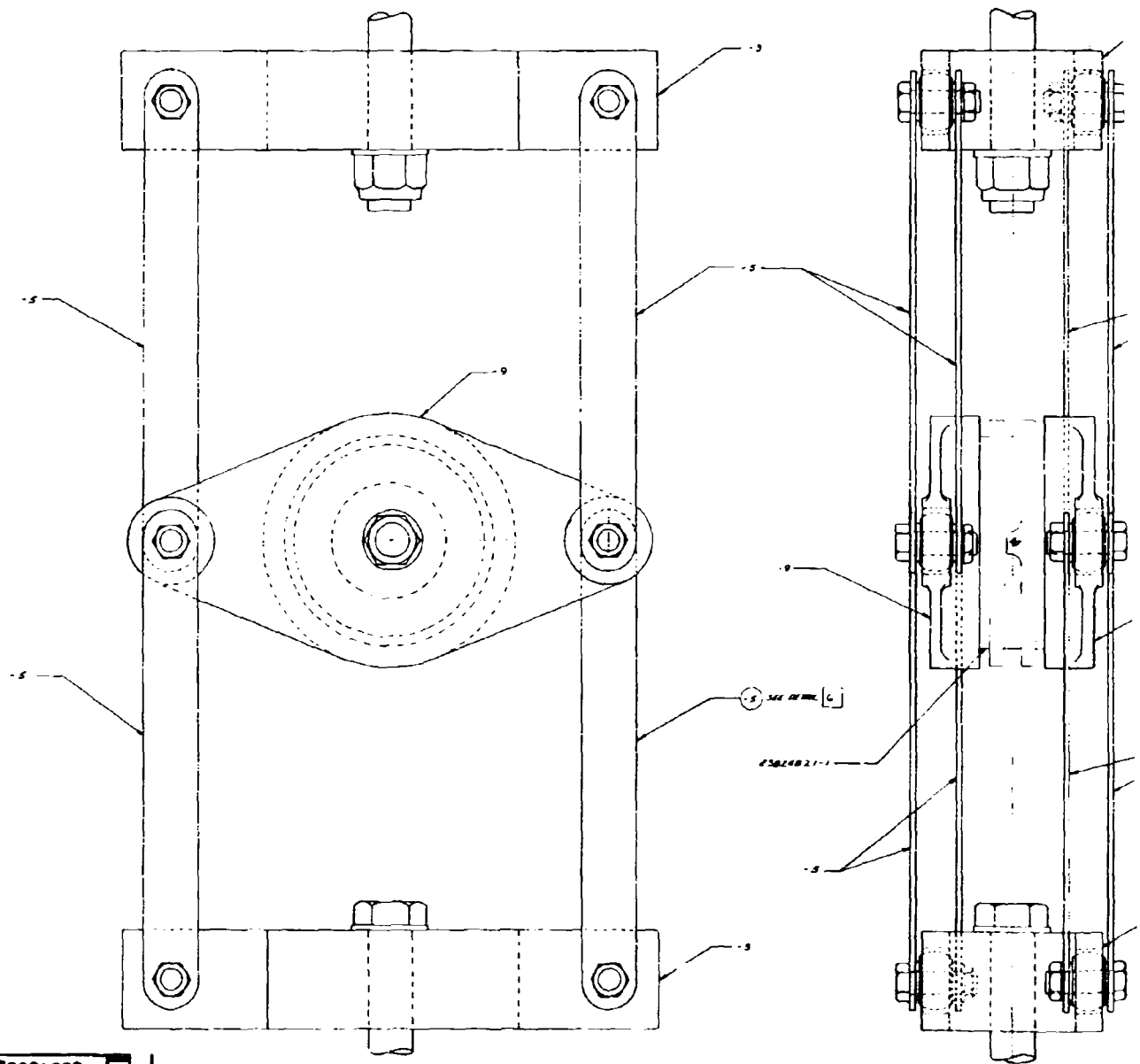
25824822 1

H



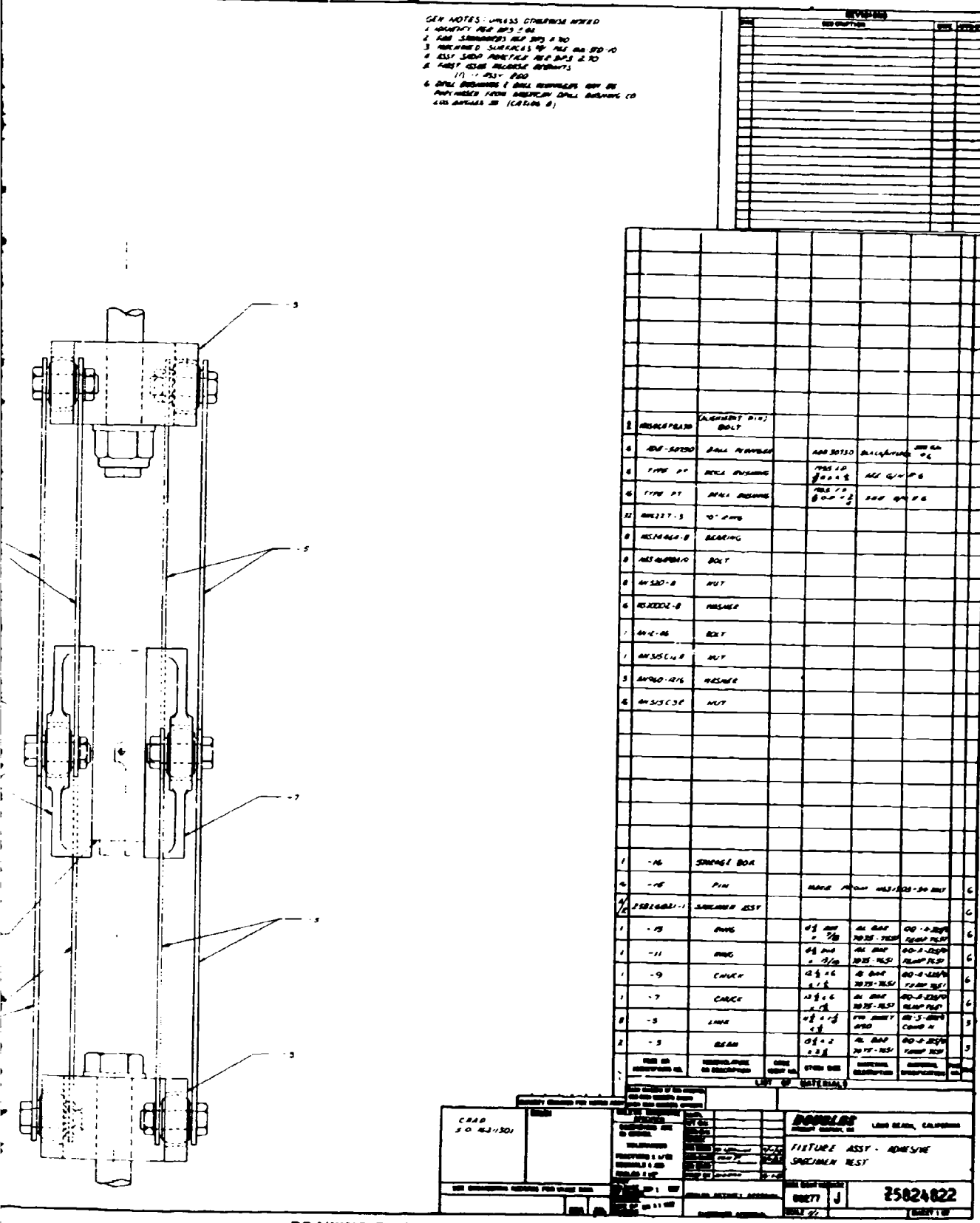
DRAWING Z5824822. FIXTURE ASSEMBLY – ADHESIVE SPECIMEN TEST

B



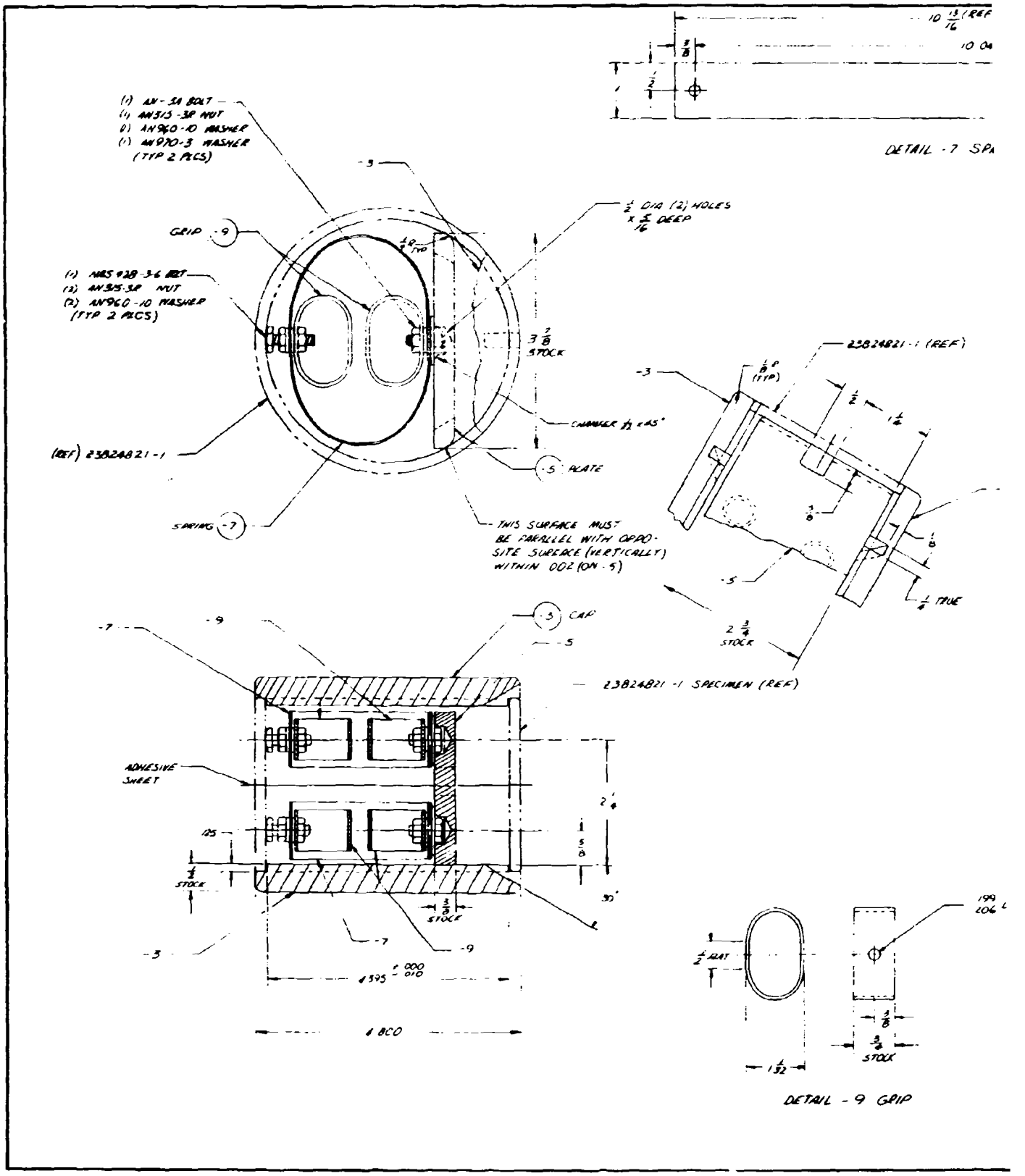
25824822

A

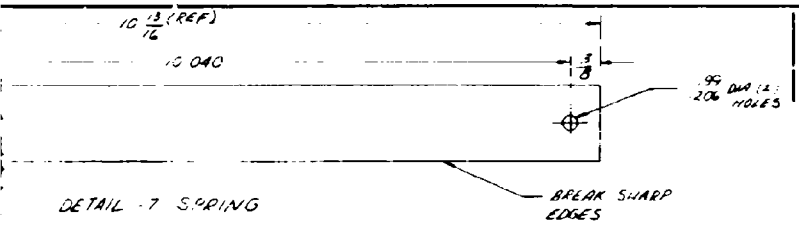


DRAWING Z5824822. FIXTURE ASSEMBLY – ADHESIVE SPECIMEN TEST (CONTINUED)

B


(1) AN-3A BOLT
(1) AN315-3P NUT
(1) AN960-10 WASHER
(1) AN970-3 WASHER
(TYP 2 PLCS)
-9
GRIP -9
(1) NAS 428-3-6 BRT
(2) AN315-3P NUT
(2) AN960-10 WASHER
(TYP 2 PLCS)
(REF) 23824821-1
SPRING -7
1/2 DIA (2) HOLES
X 5/16 DEEP
1/2 TYP
3 3/8 STOCK
CHAMFER 1/16 x 45°
-5 PLATE
THIS SURFACE MUST
BE PARALLEL WITH OPPO-
SITE SURFACE (VERTICALLY)
WITHIN .002 (ON -5)
10 13/16 REF
10.04
3/8
1/2
1
DETAIL -7 SPA
23824821-1 (REF)
1/8 R
(TYP)
-3
1/2
1 1/4
3/8
1/8
-5
1/4 TRUE
2 3/4
STOCK
23824821-1 SPECIMEN (REF)
-3 CAP
-5
-7
-9
ADHESIVE
SHEET
.125
1/2
STOCK
2 1/4
1 5/8
35°
3/8
STOCK
-7
-9
-3
4.395 +.000 -.010
4.800
1.99
2.06
1
1/2 FLAT
3/8
3/4
STOCK
1 1/32
DETAIL - 9 GRIP

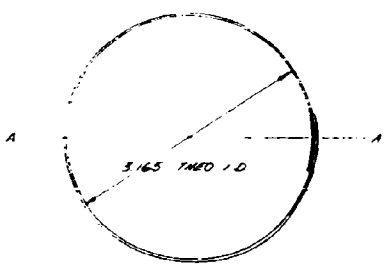
H



DETAIL -7 SPRING

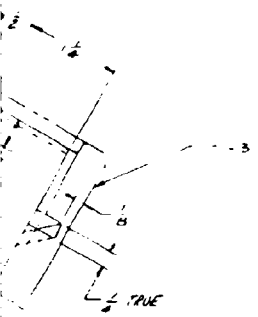
REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

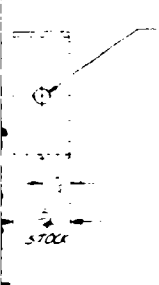
GEN NOTES: UNLESS OTHERWISE NOTED
1. IDENTIFY PER DPS 3.02
2. FAB STANDARDS PER DPS 4.710
3. ASSY SHOP PRACTICE PER DPS 2.70
4. FIRST ISSUE RELEASE REQMNTS:
(S) -1 ASSY REQ'D



FREE POSITION OF -7
ADJUST LENGTH OF DIAMETER
ALONG AXIS A-A TO OBTAIN 5 ±1 LB
AT INSTALLED POSITION IF REQ

Z3824821-1 (REF)





QTY	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	STOCK SIZE	MATERIAL DESCRIPTION	MATERIAL SPECIFICATION	PROD SEC
2	AN 3A	BOLT					
6	AN315-3R	NUT					
6	AN960-10	WASHER					
2	AN970-3	WASHER					
2	NAS 428-3-6	BOLT					
4	-9	GRIP		1/4 O.D. x .065 WALL	AL TUBE 2024-T3	WW-T-700/3 TYPE I TEMP T3	
2	-7	SPRING		10 13/16 x 1 x .025	CRES STRIP	MIL-S-5059 CONDITION A TEMPER 3/4 H	
1	-5	PLATE		5 3/8 x 2 3/4 x 3/32	AL PLATE 202A-T351	QQ-A-250/4 TEMP T351	
2	-3	CAP		5 DIA x 1/2	AL BAR 2024-T351	QQ-A-225/6 TEMP T351	

LIST OF MATERIALS

QUANTITY REQUIRED PER NOTED ASSY

FINISH

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES.
TOLERANCES
FRACTIONS ± 1/32
DECIMALS ± .005
ANGLES ± 1/2°

MATL
WT CHK
STR CHK
CHK
PROJ ENGR
DES ENGR
QR ENGR
PROJ ENGR DIORAK

DOUGLAS AIRCRAFT COMPANY, INC. LONG BEACH, CALIFORNIA

FIXTURE ASSY - ADHESIVE SPECIMEN BONDING ALIGNMENT

PRINT RELEASE OF PRINTS FOR MFG
DATE OF RELEASE JUN 16 1967

ENGRG ACTIVITY APPROVAL
CUSTOMER APPROVAL

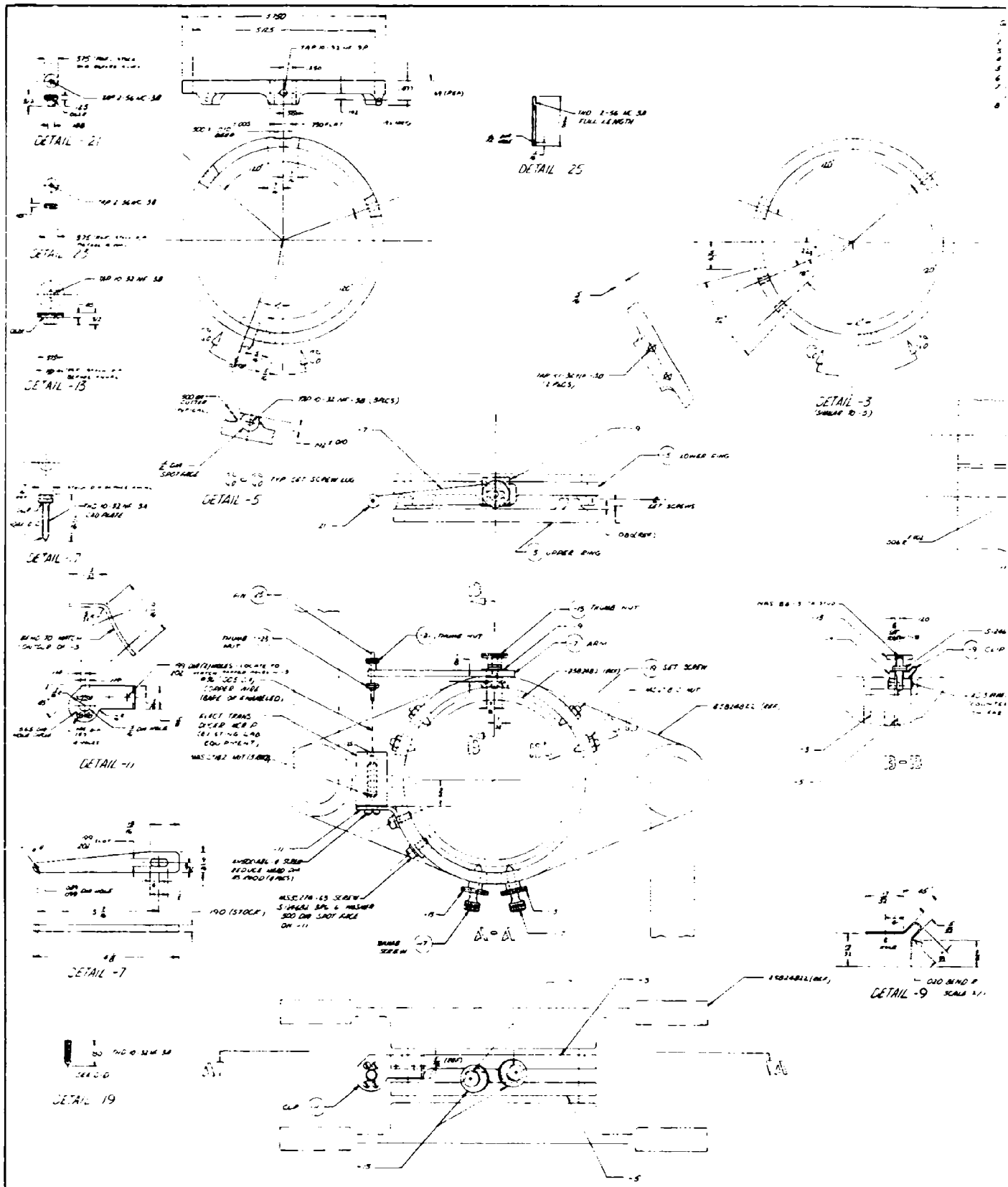
CODE IDENT NO. 88277 | SIZE D | Z3824823

SCALE 1/1 | SHEET 1 OF 1

AEL ENGINEERING RECORDS FOR USAGE DATA

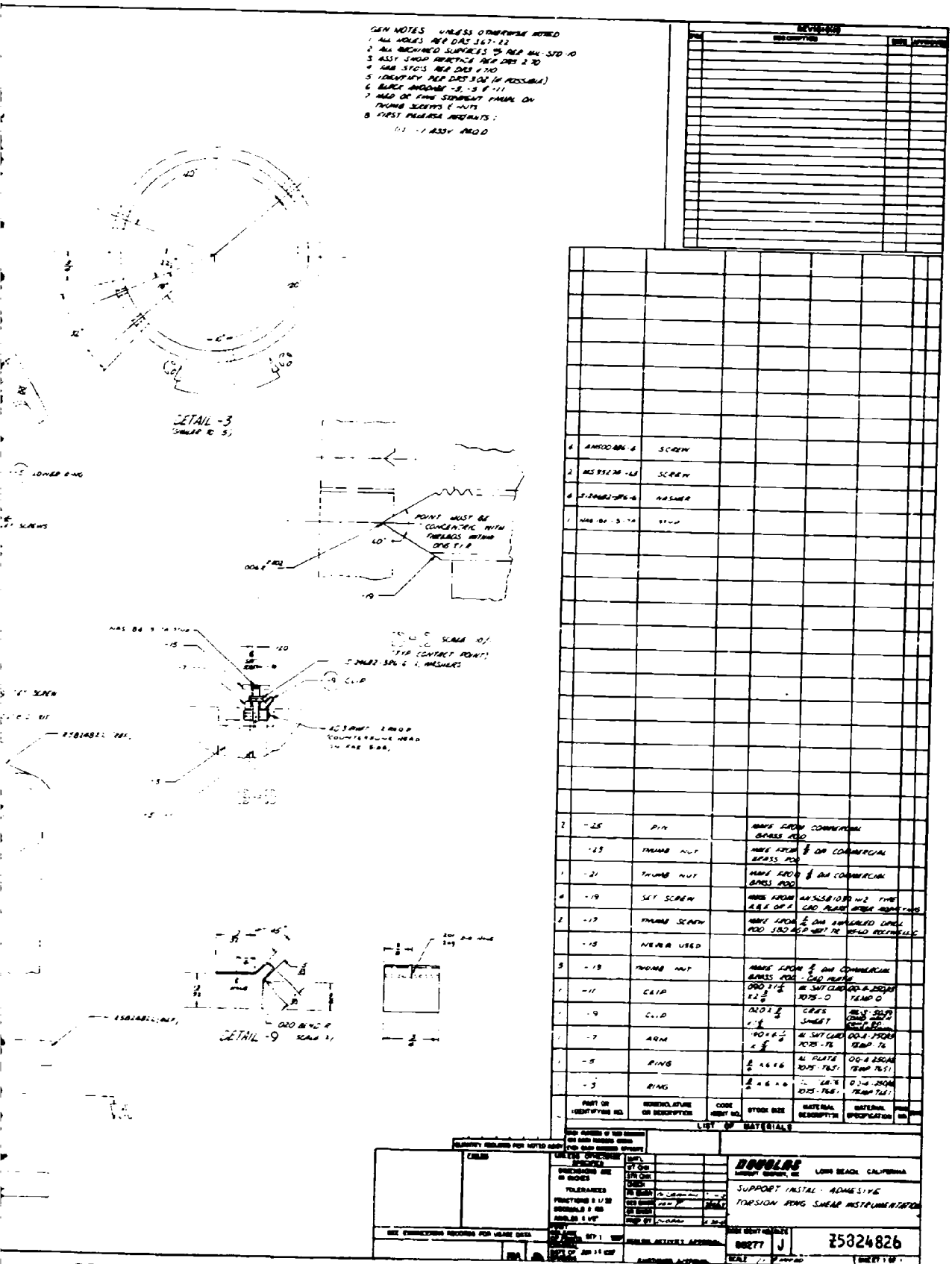
DRAWING Z3824823. FIXTURE ASSEMBLY – ADHESIVE SPECIMEN BONDING ALIGNMENT

B

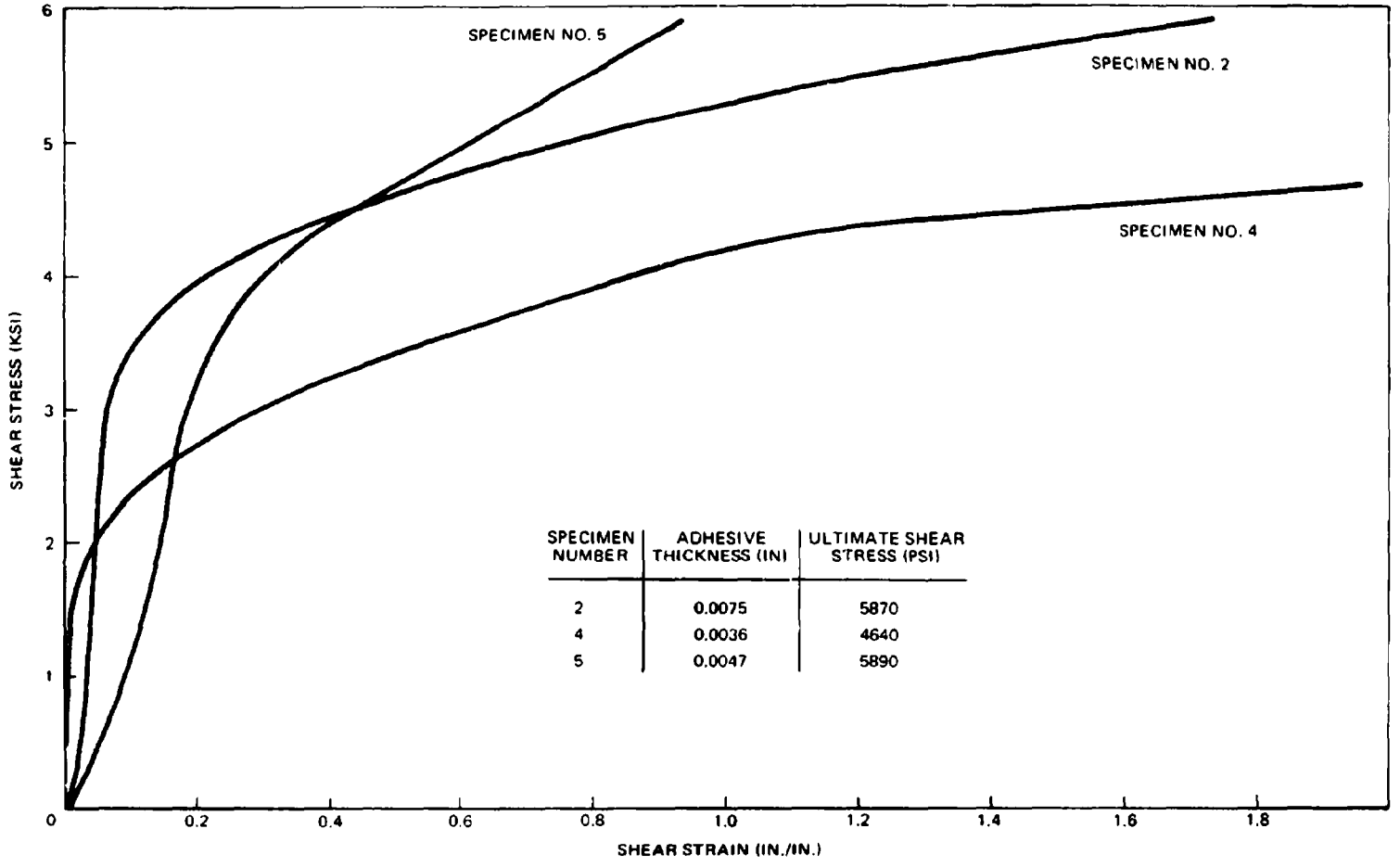


DRAWING Z5824826. SUPPORT INS

4



DRAWING Z5824826. SUPPORT INSTALLATION – ADHESIVE TORSION RING SHEAR INSTRUMENTATION



SPECIMEN NUMBER	ADHESIVE THICKNESS (IN)	ULTIMATE SHEAR STRESS (PSI)
2	0.0075	5870
4	0.0036	4640
5	0.0047	5890

FIGURE 85. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE

SPECIMEN NUMBER	ADHESIVE THICKNESS (IN.)	ULTIMATE SHEAR STRESS (PSI)
2	0.0089	3150
3	0.0113	3075
4	0.0150	1670

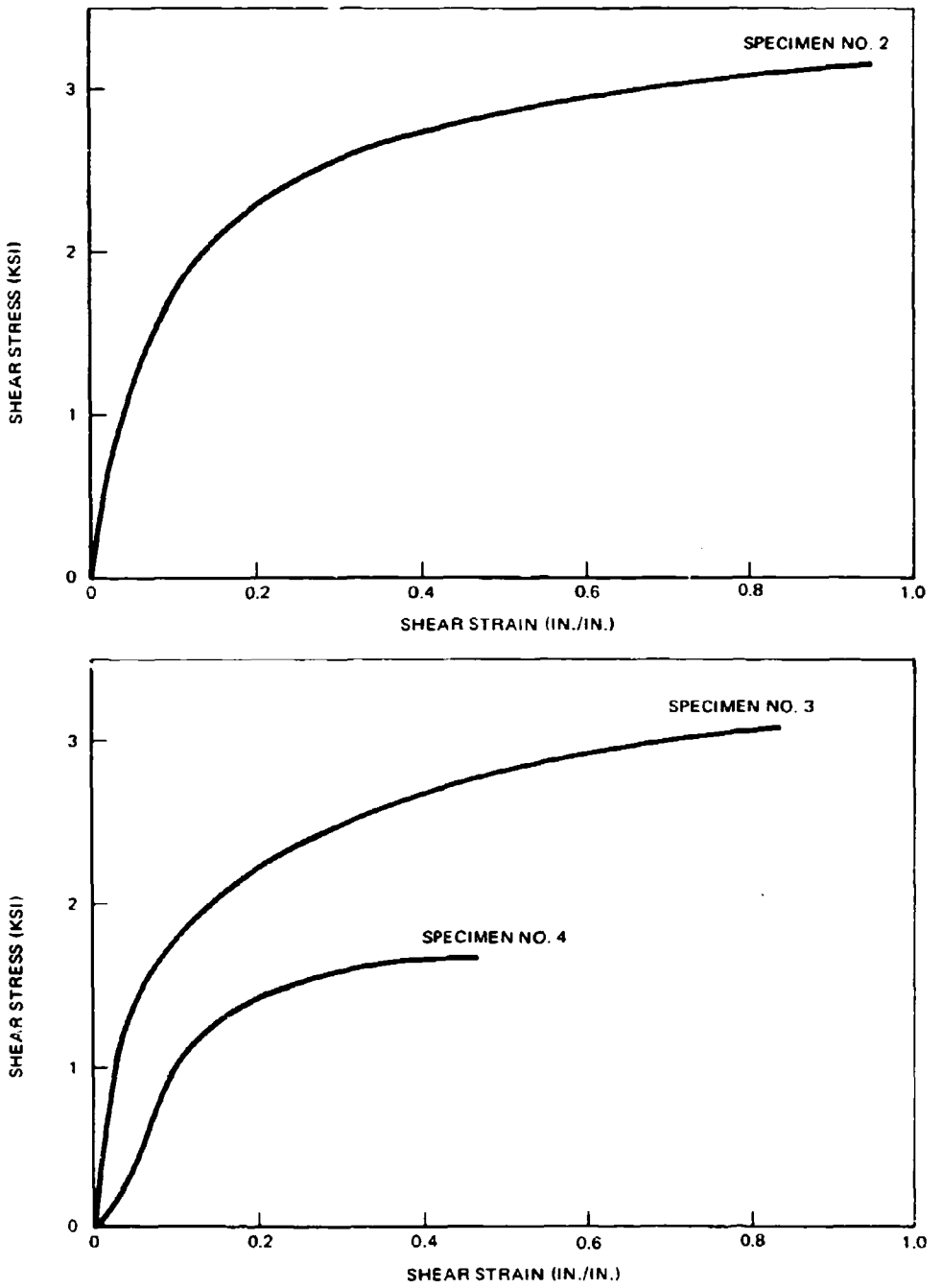


FIGURE 86. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR NARMCO 252 ADHESIVE

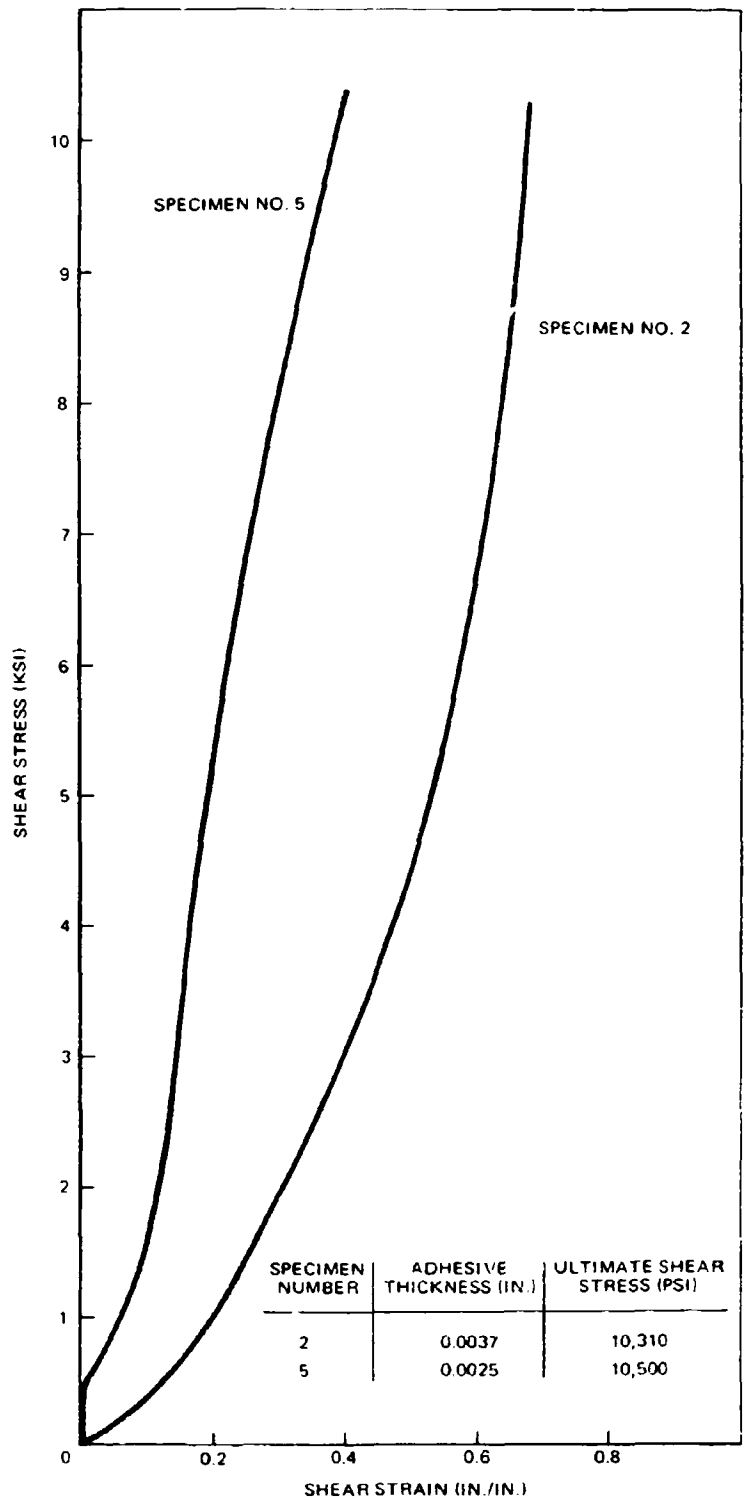


FIGURE 87. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR AF130 ADHESIVE

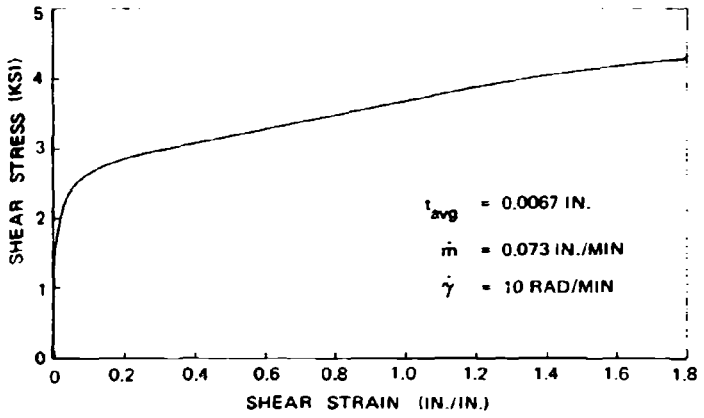


FIGURE 88. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE (A)

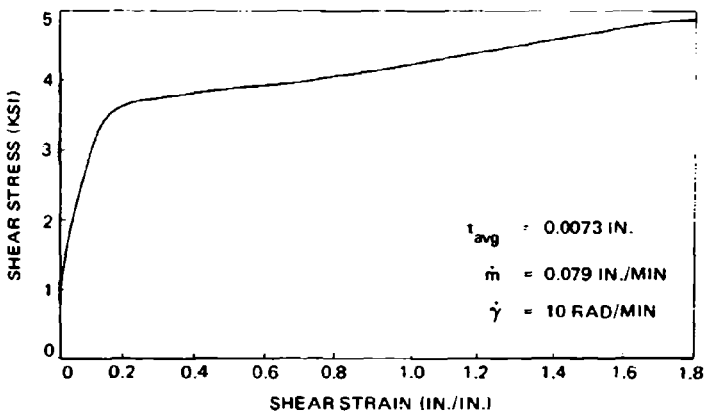


FIGURE 89. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE (B)

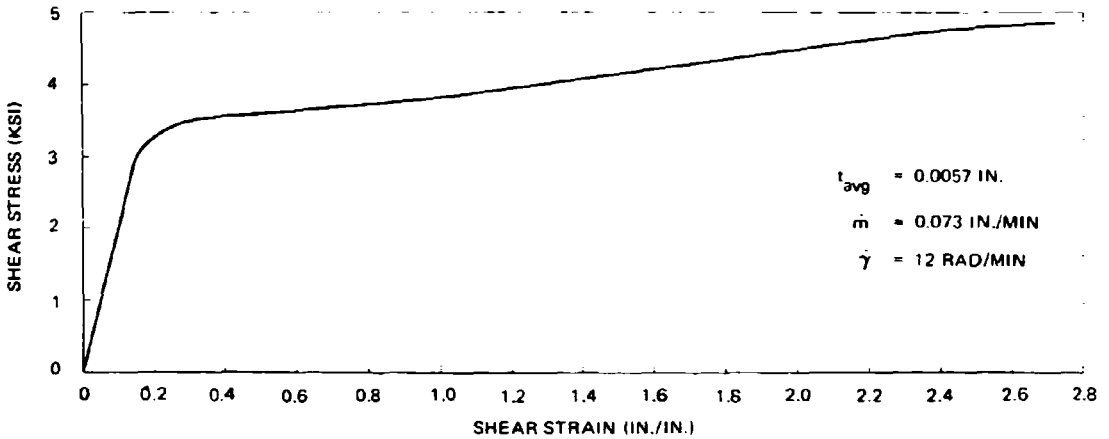


FIGURE 90. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE (C)

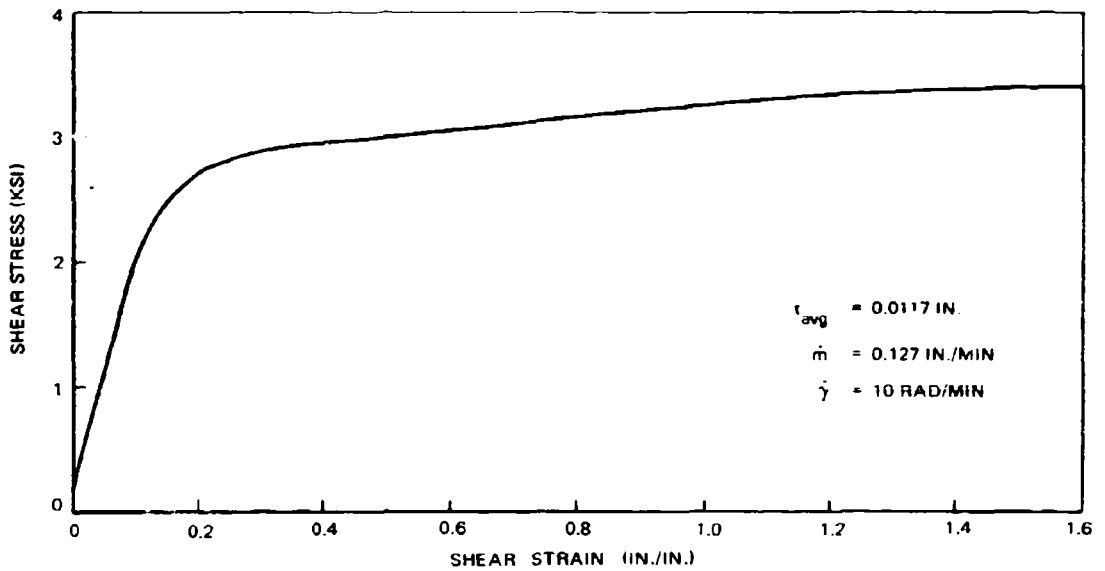


FIGURE 91. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE (D)

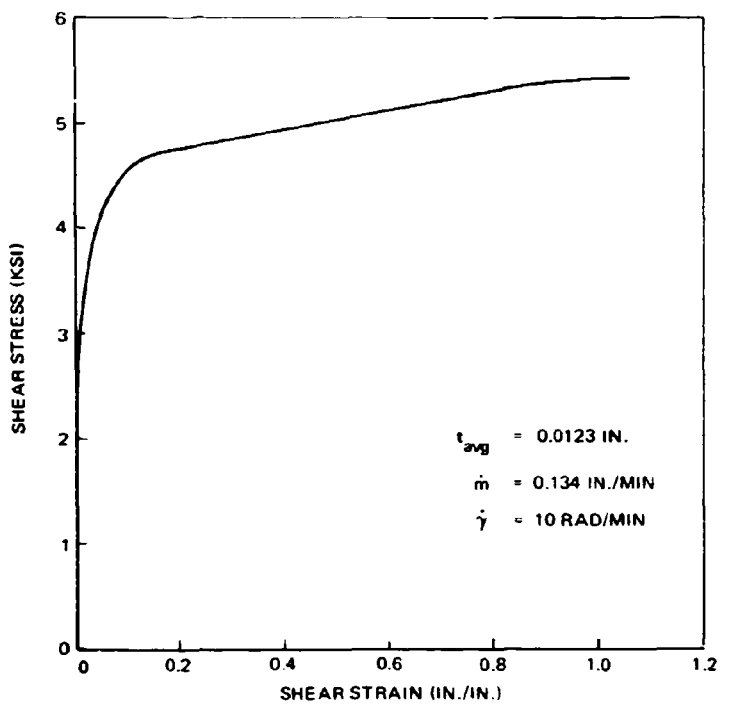


FIGURE 92. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE (E)

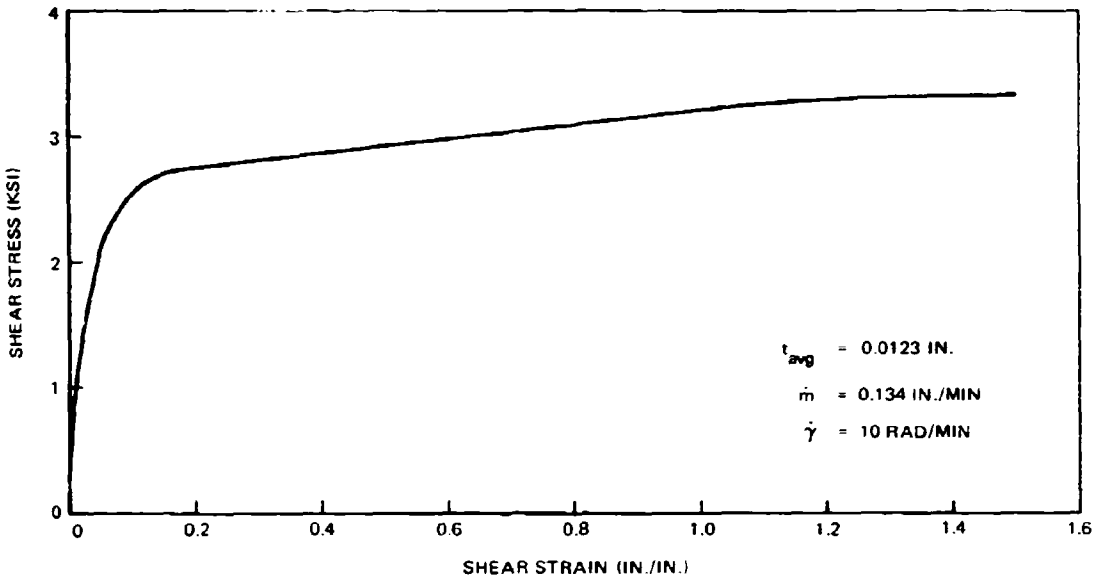


FIGURE 93. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE (F)

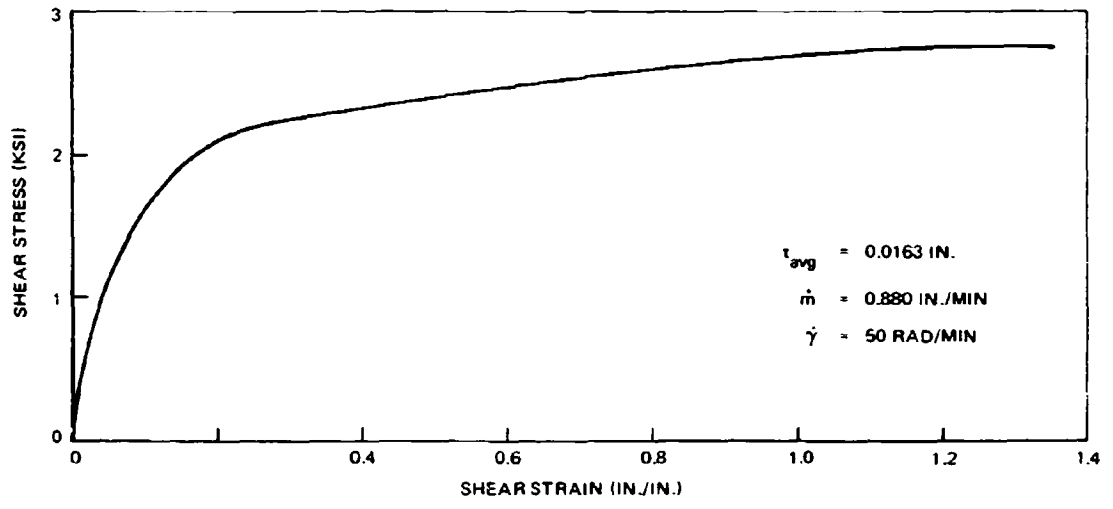


FIGURE 94. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE (G)

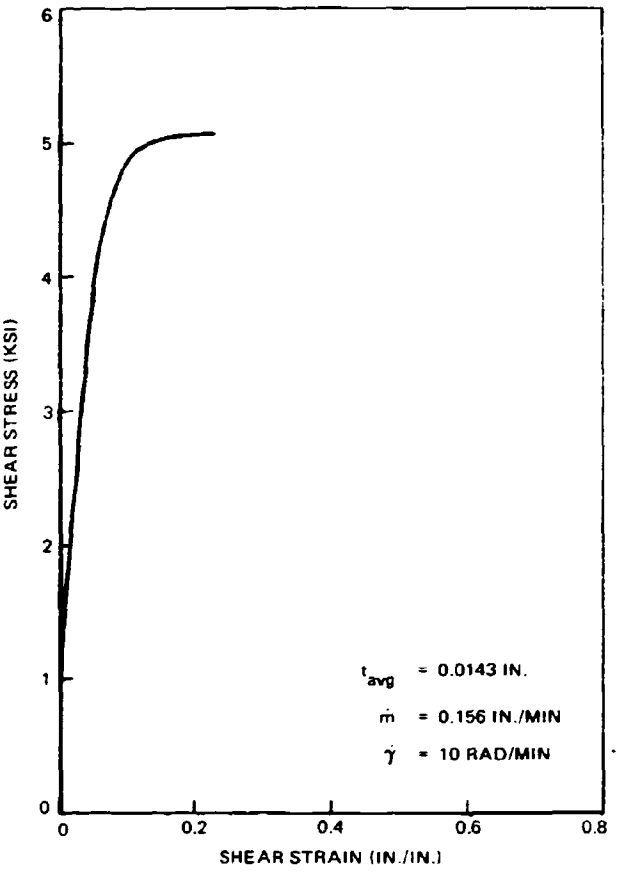


FIGURE 95. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE (H)

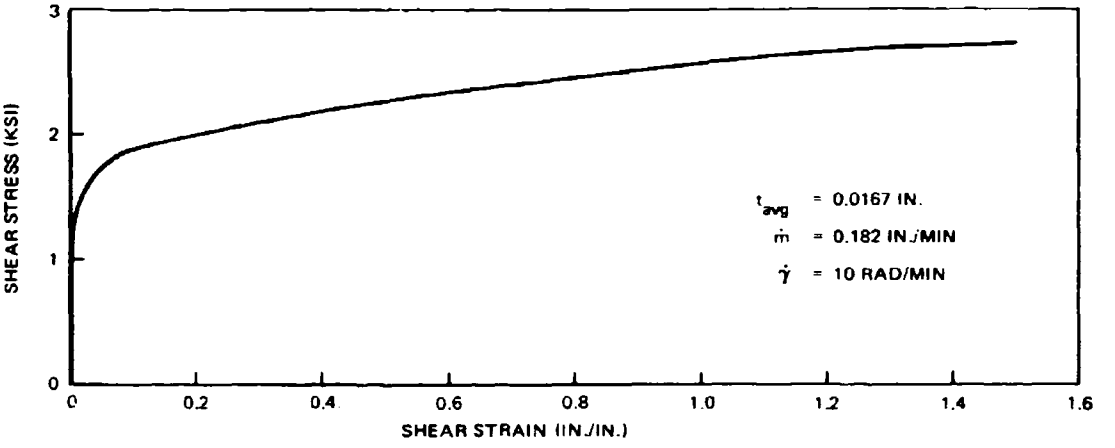


FIGURE 96. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE (I)

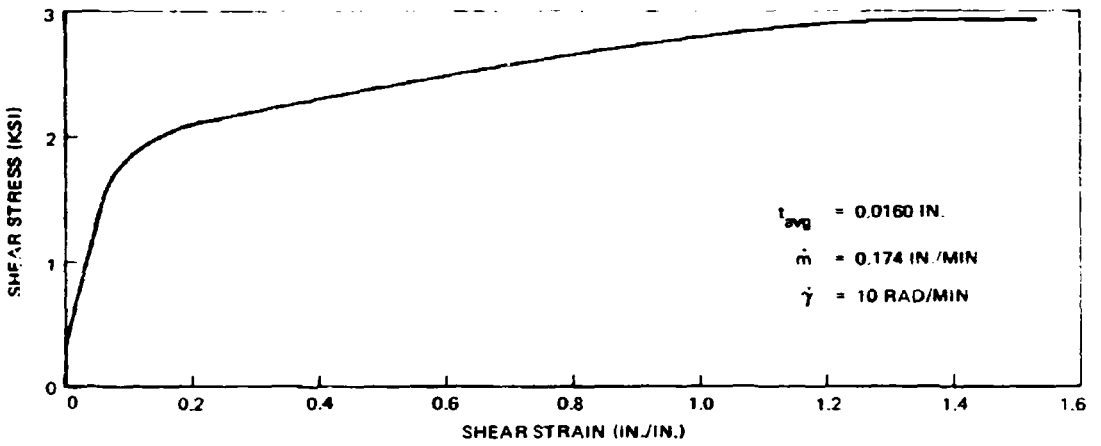


FIGURE 97. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE (J)

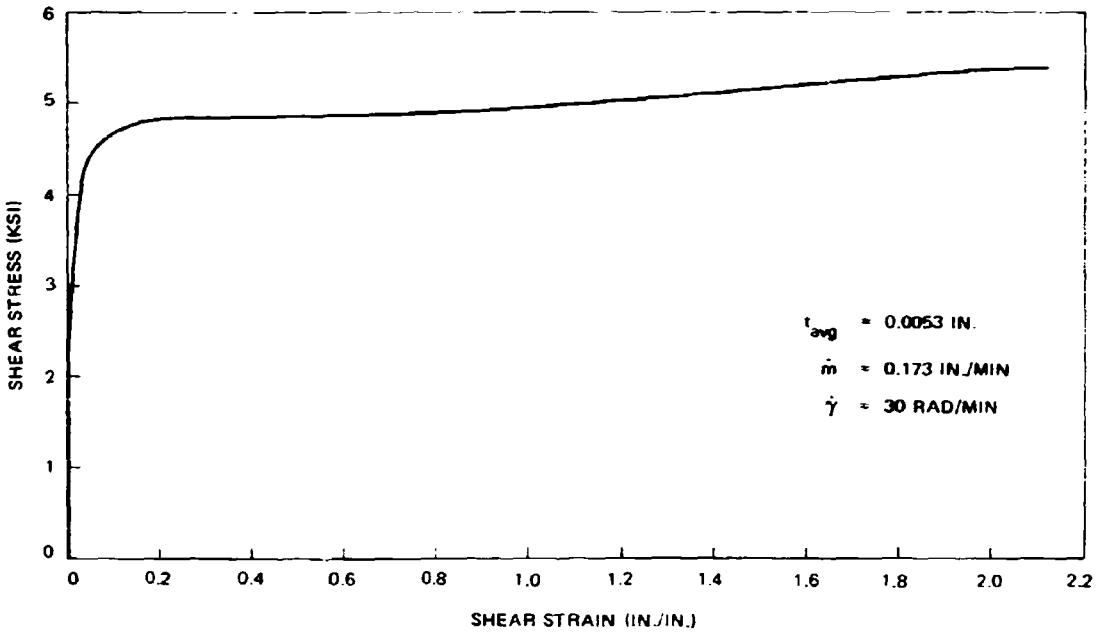


FIGURE 98. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE (K)

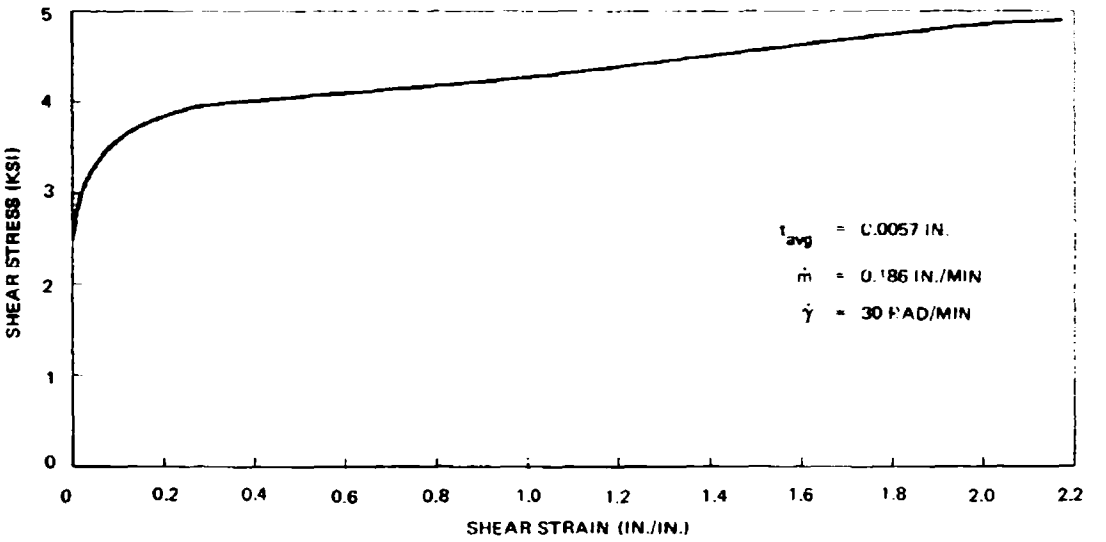


FIGURE 99. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE (L)

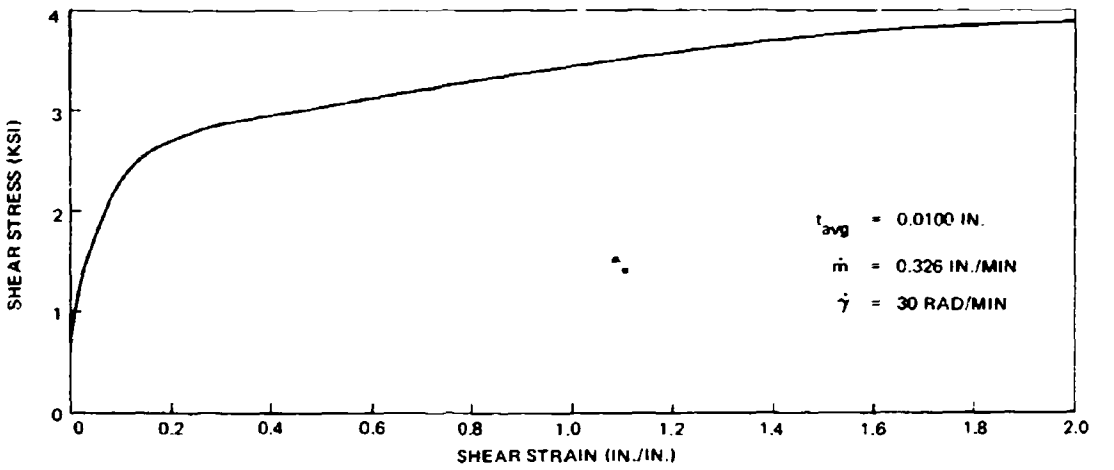


FIGURE 100. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE (M)

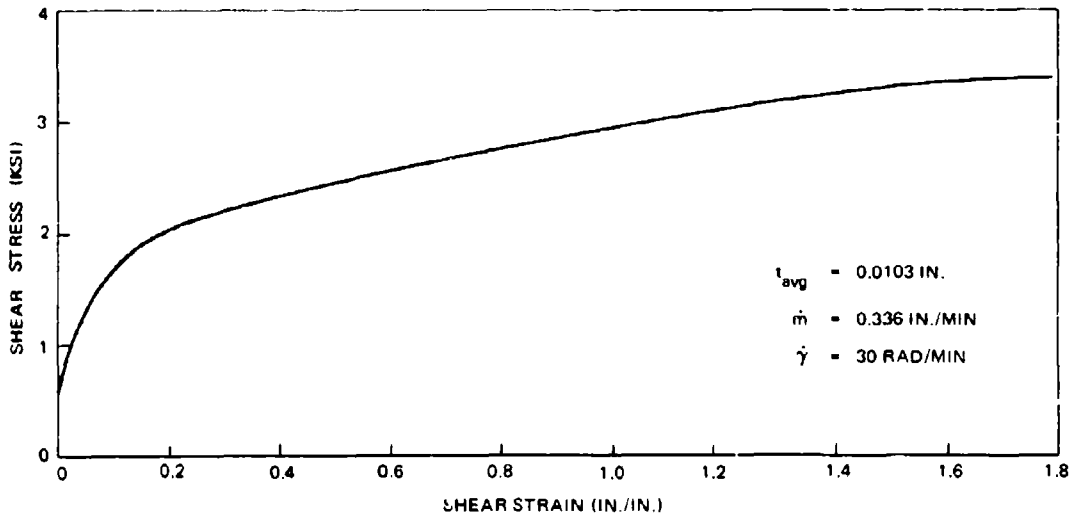


FIGURE 101. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE (N)

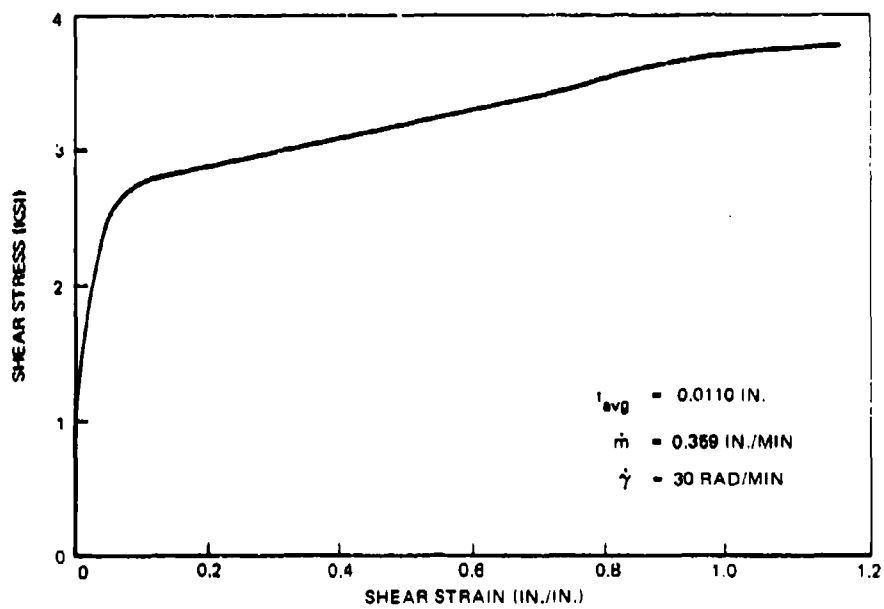


FIGURE 102. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE (O)

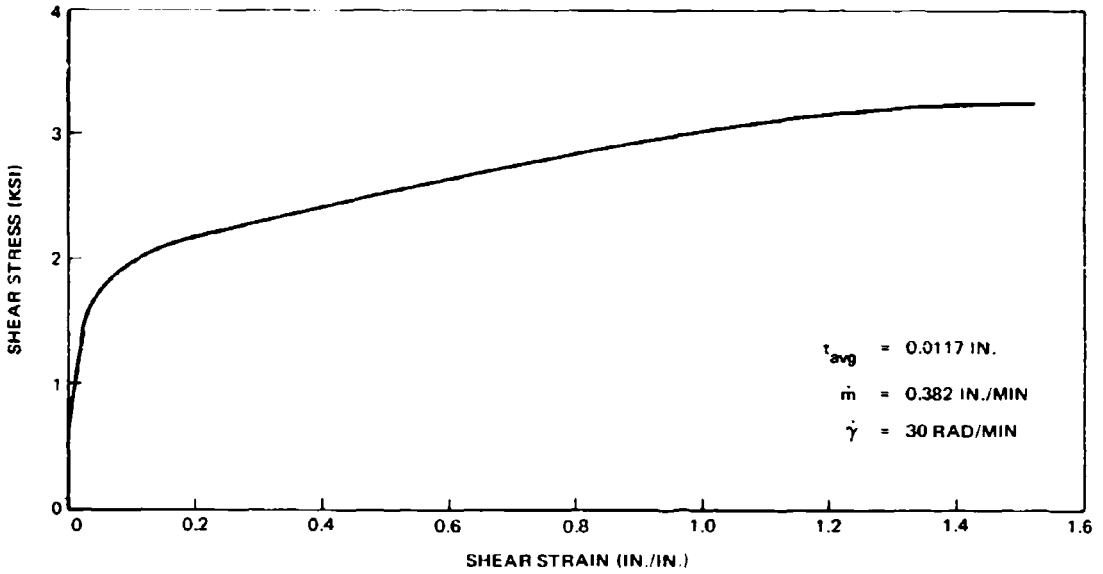


FIGURE 103. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE (P)

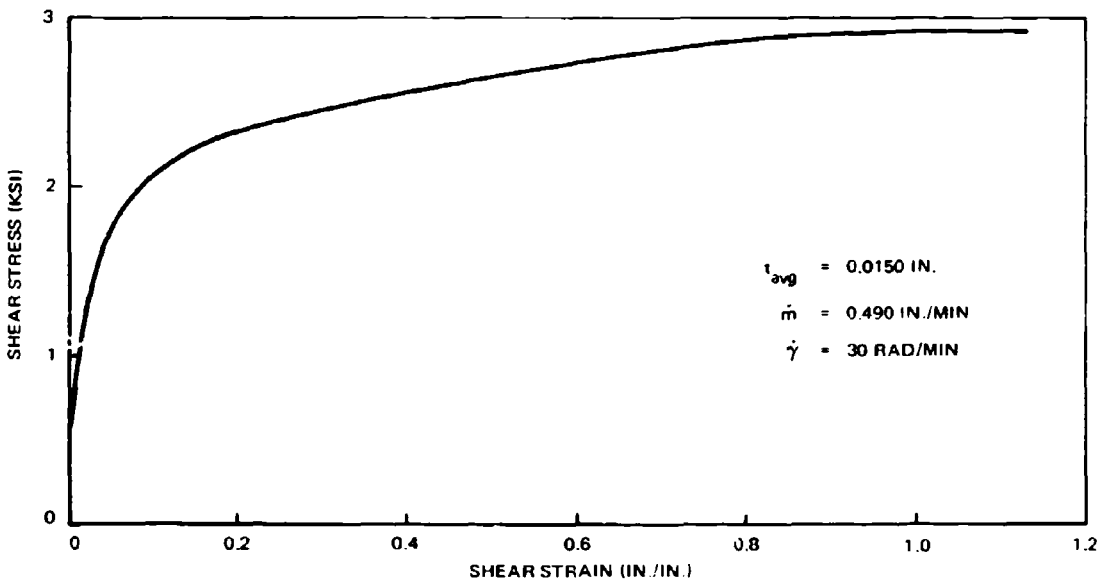


FIGURE 104. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE (Q)

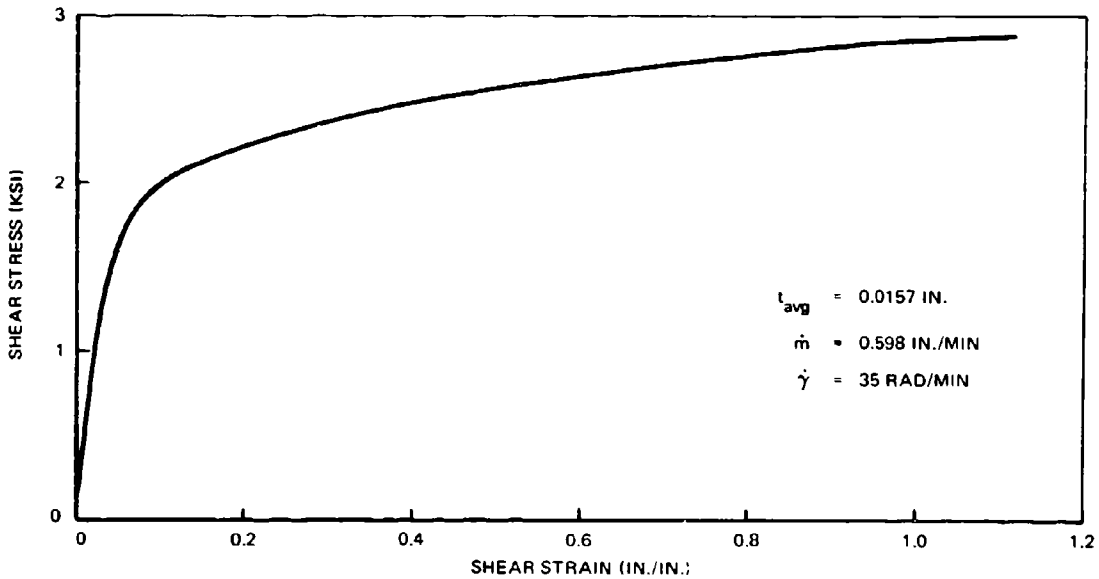


FIGURE 105. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE (R)

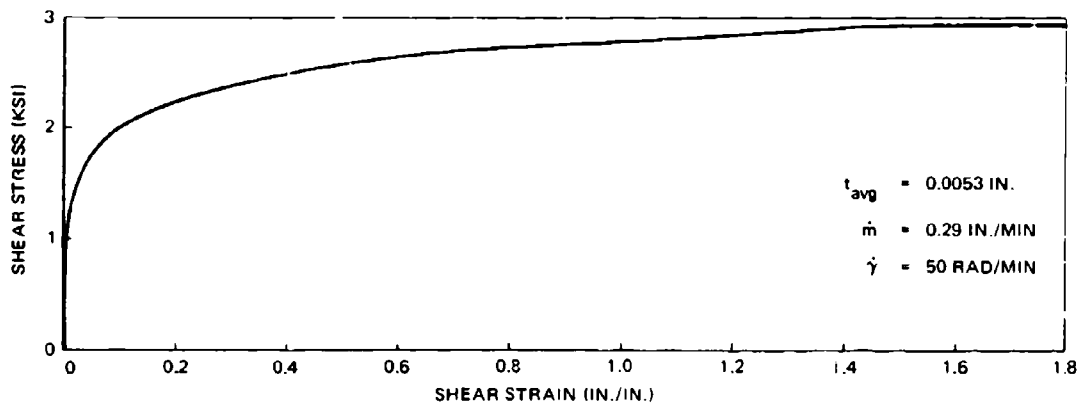


FIGURE 106. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE (S)

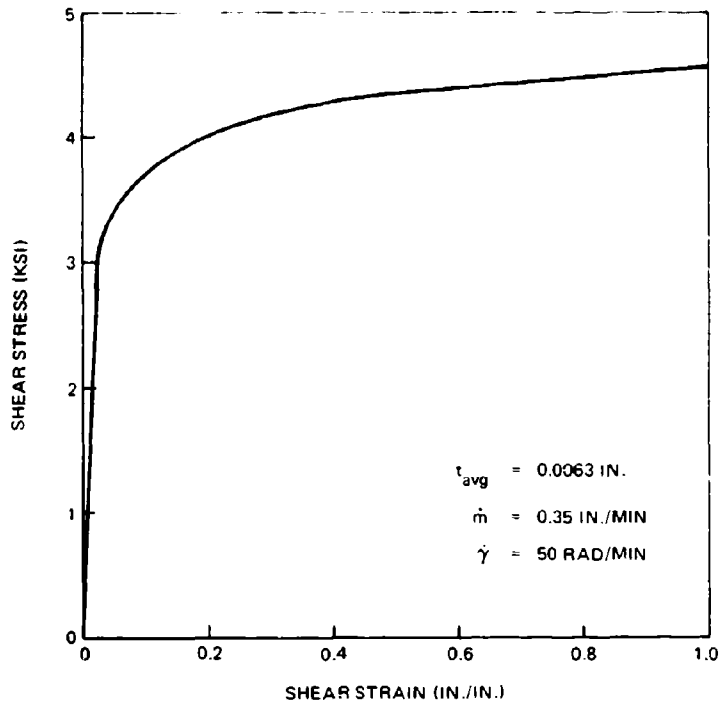


FIGURE 107. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE (T)

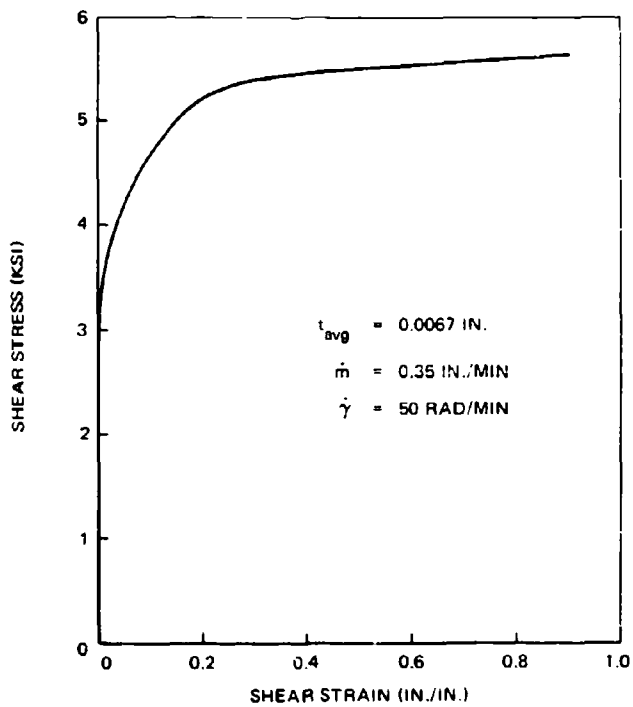


FIGURE 108. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE (U)

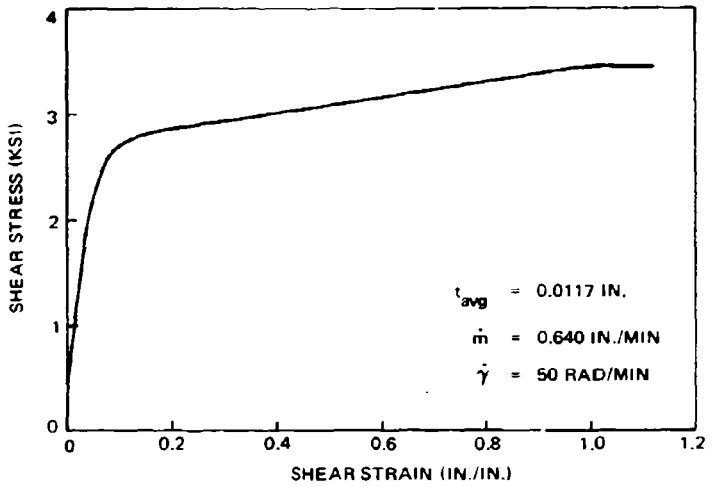


FIGURE 109. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE (V)

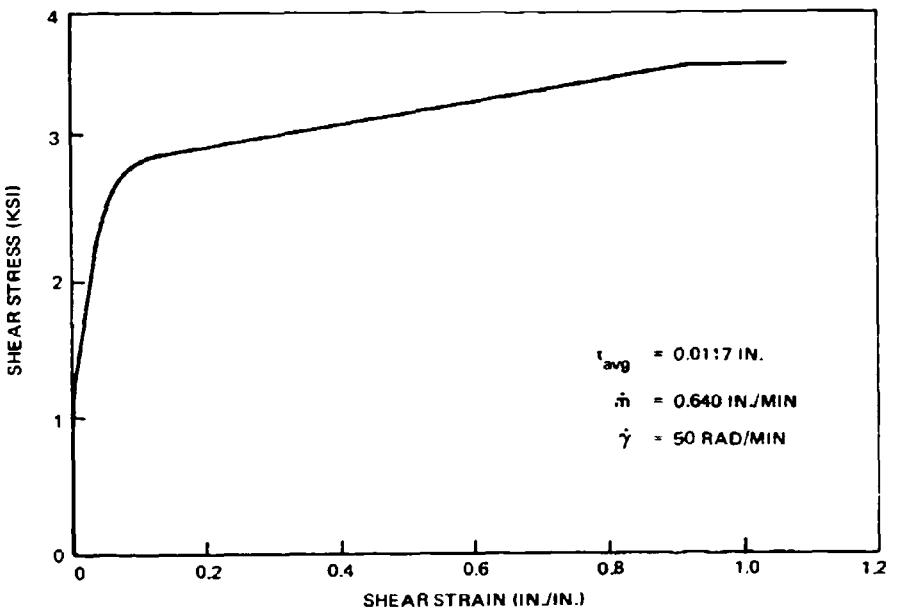


FIGURE 110. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE (W)

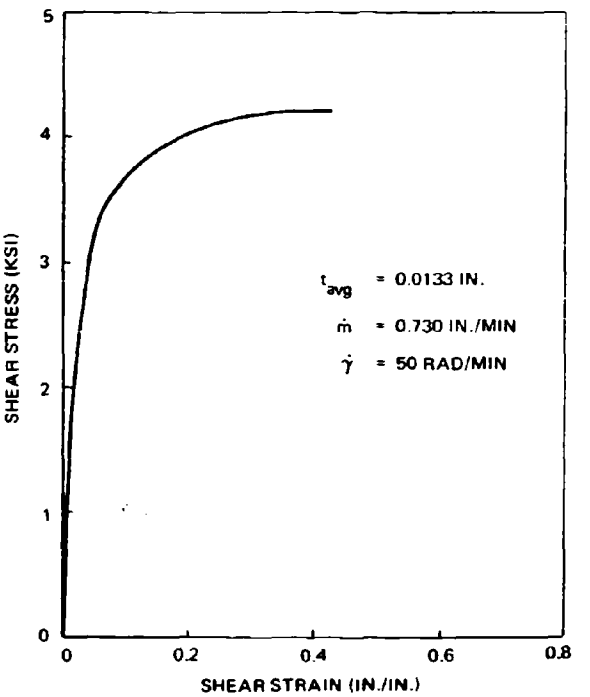


FIGURE 111. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE (X)

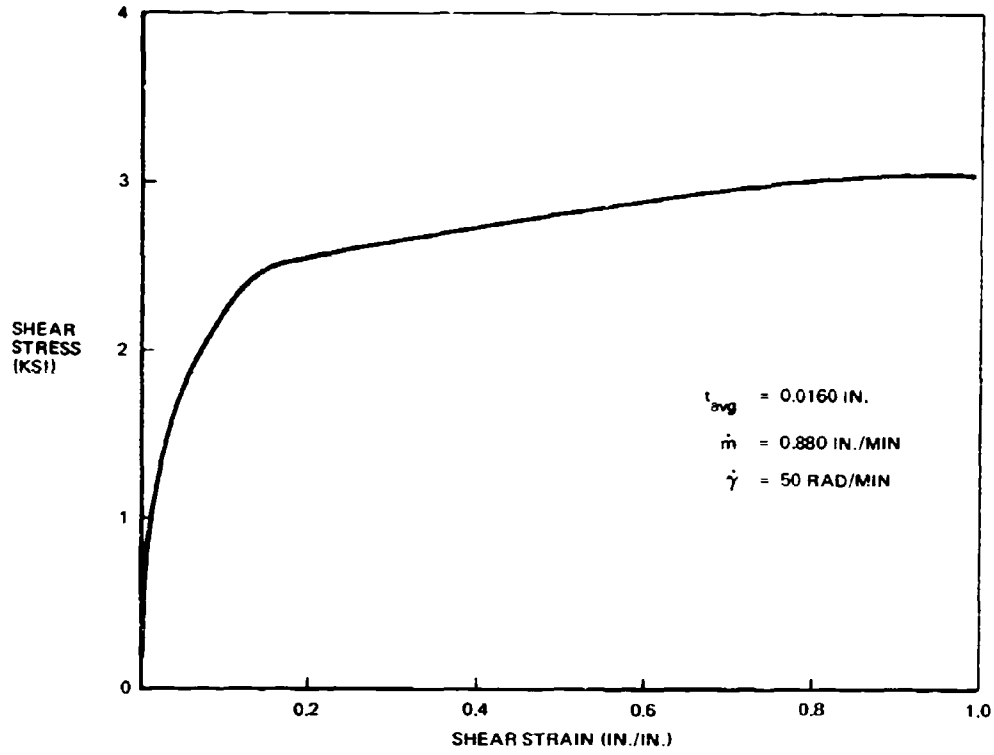


FIGURE 112. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE (Y)

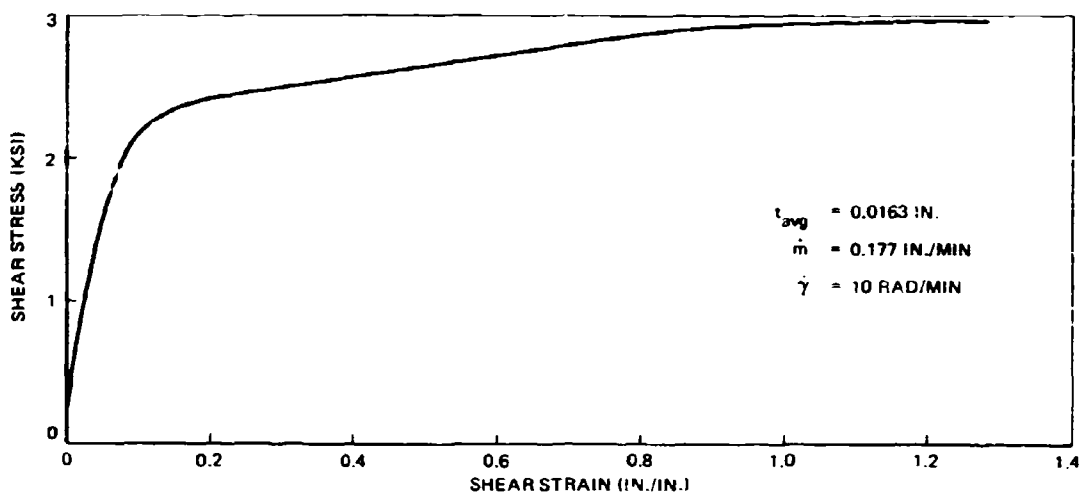


FIGURE 113. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE (Z)

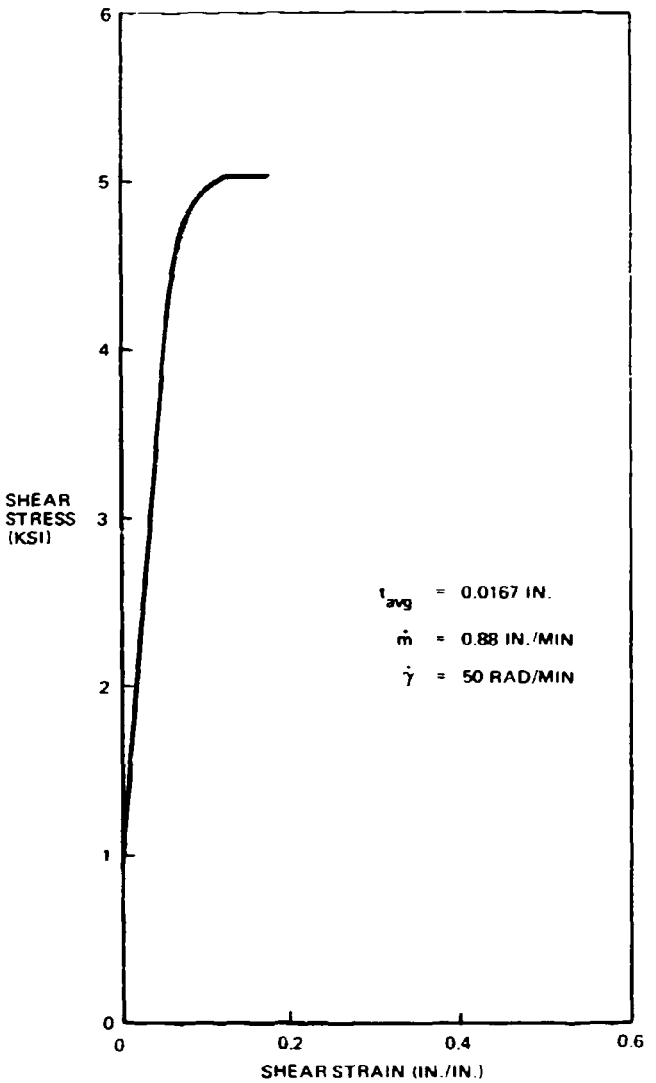


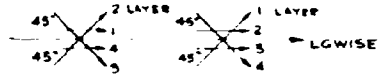
FIGURE 114. TORSIONAL SHEAR STRESS-STRAIN DIAGRAM FOR SHELL 951 ADHESIVE (AA)

SECTION II

JOINT TESTS

GEN NOTES: UNLESS OTHERWISE STATED

1 IDENTIFY PER DPS 5 02
2 SPECIMEN FAB & PROCESSING METHODS PER DPS 4 63 - Z 5824827
3 BOND WITH SHELL 951 ADHESIVE
4 LAMINATES ARE MADE UP OF MULTIPLES OF THE FOLLOWING PATTERNS:



A B

IN EACH CASE LAYER 1 IS THE OUTERMOST LAYER AND LAY-UP IS SYMMETRICAL ABOUT THE MID-PLANE OF THE LAMINATE

5. FIRST ISSUE RELEASE REQUIREMENTS: 5 EA REQ -* THRU -521
6 # 1 INCH OVERLAP DRAWN. ½ & 2 INCH OVERLAPS SIMILAR SEE TABLE FOR DETAILS OF CONFIGURATIONS
7 FINISH PER DPS 907: PROCESS PER DPS 4 806 FOR -45, -45 & -47
8 HT TR 17-TPH COND A TO HR 210 PER DPS 500
9 PROCESS TITANIUM PER DPS 4 801
10 RELEASE REQUIREMENTS 3 EA REQ -523 THRU -545

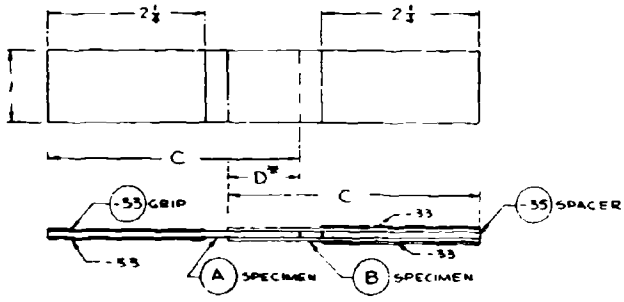
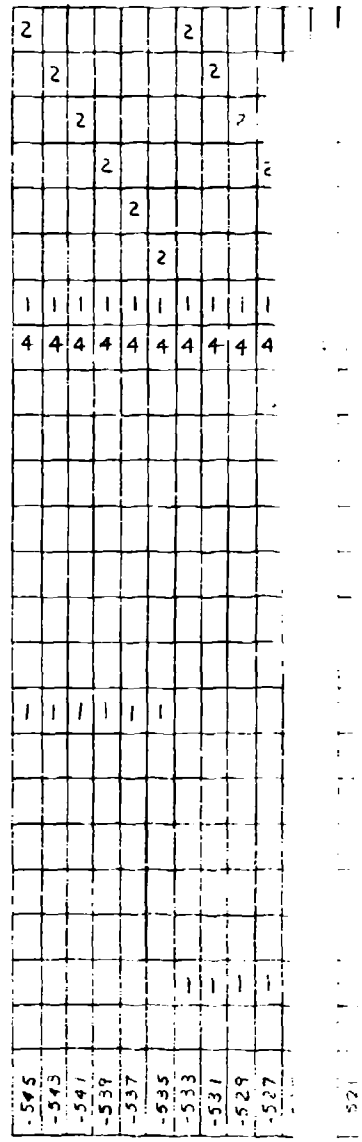
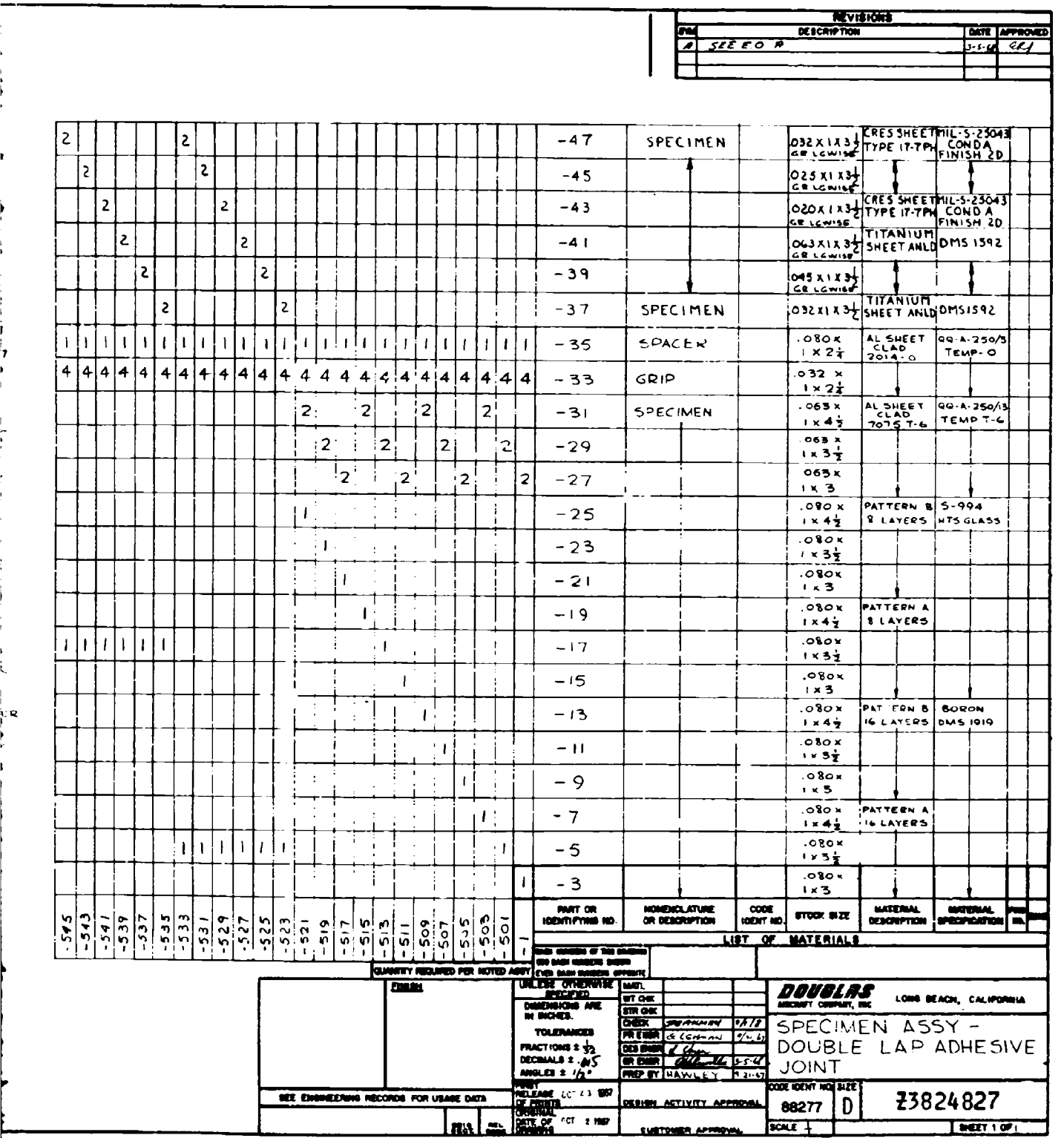


TABLE OF CONFIGURATIONS

CONFIG-URATION	A	B	C	D
-1	-3	-27	3	½
-501	-5	-29	3½	1
-503	-7	-31	4½	2
-505	-9	-27	3	½
-507	-11	-29	3½	1
-509	-13	-31	4½	2
-511	-15	-27	3	½
-513	-17	-29	3½	1
-515	-19	-31	4½	2
-517	-21	-27	3	½
-519	-23	-29	3½	1
-521	-25	-31	4½	2



A



DRAWING Z3824827. SPECIMEN ASSEMBLY – DOUBLE LAP ADHESIVE JOINT

TABLE IV
DOUBLE LAP ADHESIVE JOINT STRENGTH SUMMARY
(SHELL 951 ADHESIVE – 1-INCH SPECIMEN WIDTH)

CONFIGURATION Z3824827	SPECIMEN MATERIAL	BOND LINE DATA		ULTIMATE LOAD (LB)	ULTIMATE STRESS (PSI)
		ACTUAL THICKNESS (IN.)	AREA (SQ. IN.)		
-1	BORON TO ALUMINUM	0.0015	1.010	6000	5941
		0.001	1.023	5985	5850
		0.001	1.021	5275	5167
		0.001	1.036	6335	6116
		0.001	1.039	5260	5053
				AVG 5769	AVG 5625
-501	BORON TO ALUMINUM	0.001	2.030	9150	4507
		0.001	–	9275	4640*
		0.002	–	9360	4680*
		0.001	2.028	9410	4640
		0.001	2.042	8325	4070
FEB 1968				AVG 9104	AVG 4406
-501	BORON TO ALUMINUM	0.002	2.000*	9700	4850Δ
		0.002	2.000*	9685	4840Δ
REPEATED		0.002	2.000*	9955	4980Δ
		0.002	2.000*	9675	4840Δ
		0.002	1.980	9715	4900
JAN 1969				AVG 9746	AVG 4882
-503	BORON TO ALUMINUM	0.001	4.000*	9150	2290*
		0.001	4.000*	9250	2310**
		0.001	4.000*	9605	2400*
		0.001	4.000*	9315	2330*
		0.001	4.000*	9570	2390*
				AVG 9378	AVG 2340
-505	BORON TO ALUMINUM	0.001	1.040	6100	5865
		0.0015	1029	6525	6341
		0.0015	1020	6075	5956
		0.0025	1.042	5775	5542
		0.001	1.033	5435	5261
				AVG 5982	AVG 5793
-507	BORON TO ALUMINUM	0.001	2.000*	8300	4150Δ
		0.001	2.000*	8625	4300Δ
		0.0015	2.000*	8300	4150Δ
		0.001	2.000*	8120	4060Δ
		0.0015	2.000*	8290	4145Δ
FEB 1968				AVG 8327	AVG 4160

*STRESS CALCULATIONS ARE BASED ON NOMINAL SPECIMEN DIMENSIONS.

TABLE IV
DOUBLE LAP ADHESIVE JOINT STRENGTH SUMMARY (Continued)
(SHELL 951 ADHESIVE – 1-INCH SPECIMEN WIDTH)

CONFIGURATION Z3824827	SPECIMEN MATERIAL	BOND LINE DATA		ULTIMATE LOAD (LB)	ULTIMATE STRESS (PSI)
		ACTUAL THICKNESS (IN.)	AREA (SQ IN.)		
-507	BORON TO ALUMINUM	0.003	2.000*	9350	4675Δ
		0.002	2.000*	9365	4680Δ
REPEATED		0.003	2.000*	9475	4740Δ
		0.002	2.000*	10037	5020Δ
		0.003	2.000*	9285	4640Δ
DEC 1968				AVG 9502	AVG 4751
-509	BORON TO ALUMINUM	0.0015	4.000*	5050	1260**
		0.001	4.000*	6125	1530**
		0.0015	4.000*	7825	1950Δ
		0.0015	4.000*	6700	1670**
		0.0015	4.000*	5200	1300**
				AVG 6180	AVG 1540
-511	S-994 GLASS TO ALUMINUM	0.0015	1.049	4825	4600
		0.0030	1.021	4910	4809
		0.004	1.034	4980	4816
		0.002	0.988	5150	5213
		0.001	0.970	5325	5490
				AVG 5038	AVG 4986
-513	S-994 GLASS TO ALUMINUM	0.004	2.090	5100	2440
		0.005	2.084	5625	2699
		0.002	2.080	6175	2969
		0.003	2.090	6055	2902
		0.0025	2.072	5600	2703
				AVG 5713	AVG 2743
-515	S-994 GLASS TO ALUMINUM	0.003	3.975	5480	1379
		0.0035	3.988	5430	1367
		0.0035	3.946	5375	1362
		0.0045	3.889	4775	1228
		0.0025	3.870	5425	1402
				AVG 5297	AVG 1347

*STRESS CALCULATIONS ARE BASED ON NOMINAL SPECIMEN DIMENSIONS.

TABLE IV
DOUBLE LAP ADHESIVE JOINT STRENGTH SUMMARY (Continued)
(SHELL 951 ADHESIVE – 1-INCH SPECIMEN WIDTH)

CONFIGURATION Z3824827	SPECIMEN MATERIAL	BOND LINE DATA		ULTIMATE LOAD (LB)	ULTIMATE STRESS (PSI)
		ACTUAL THICKNESS (IN.)	AREA (SQ IN.)		
-517	S-994 GLASS TO ALUMINUM	0.0025 0.001 0.0015 0.003 0.0015	1.024 1.032 1.030 0.995 0.985	4225 3850 4125 3975 4120	4126 3731 4005 3995 4183
				AVG 4059	AVG 4008
-519	S-994 GLASS TO ALUMINUM	0.002 0.002 0.003 0.002 0.0025	2.013 2.012 2.000 1.997 2.016	4225 4300 4675 4900 4550	2099 2137 2338 2454 2257
				AVG 4530	AVG 2257
-521	S-994 GLASS TO ALUMINUM	0.003 0.0025 0.0025 0.003 0.0015	4.026 4.038 4.012 4.005 4.002	5025 4375 4290 4090 4525	1248 1083 1069 1021 1131
				AVG 4561	AVG 1110
-523 MAY 1968	BORON TO TITANIUM	0.0035 0.0055 0.0035 0.0030 0.0055	2.088 2.127 2.080 2.078 2.100	7875 7480 4685 6135 6825	3770† 3520† 2254 2952† 3246
				AVG 6600	AVG 3148
-523 REPEATED JAN 1969	BORON TO TITANIUM	0.004 0.003 0.003 0.004 0.004	2.000* 2.000* 2.000* 2.000* 2.000*	9465 8960 9650 9825 9760	4700† 4450† 4800† 4900† 4880†
				AVG 9530	AVG 4746
-525 MAY 1968	BORON TO TITANIUM	0.0035 0.0025 0.0025 0.0040 0.0025	2.005 2.031 1.978 2.069 1.988	5575 9150 8500 8425 9175	2780◇† 4510 4300 4070 4620
				AVG 8812	AVG 4375
-525 REPEATED JAN 1969	BORON TO TITANIUM	0.003 0.003 0.003 0.003 0.004	2.000* 2.000* 2.000* 2.000* 2.000*	7900 9800 9320 8665 8325	3950† 4800† 4660† 4332† 4162†
				AVG 8760	AVG 4380
-527	BORON TO TITANIUM	0.0035 0.0030 0.0055 0.0040	1.958 1.996 1.973 2.018	8125 8250 8275 7775	4145† 4130† 4190† 3854†
				AVG 8100	AVG 4088

*STRESS CALCULATIONS ARE BASED ON NOMINAL SPECIMEN DIMENSIONS.

TABLE IV
DOUBLE LAP ADHESIVE JOINT STRENGTH SUMMARY (Continued)
(SHELL 951 ADHESIVE – 1-INCH SPECIMEN WIDTH)

CONFIGURATION Z3824827	SPECIMEN MATERIAL	BOND LINE DATA		ULTIMATE LOAD (LB)	ULTIMATE STRESS (PSI)
		ACTUAL THICKNESS (IN.)	AREA (SQ IN.)		
-529	BORON TO STAINLESS STEEL	0.002 0.002 0.001 0.001 0.002	2.000 *	7000 8700 7925 7800 8900	3500 4350 3963 3900 4450 †
				AVG 8065	AVG 4040
-531	BORON TO STAINLESS STEEL	0.002 0.003 0.002 0.002 0.001	2.000 *	8675 8675 8475 8175 9250	4338 4338 4238 4088 4625 †
				AVG 8650	AVG 4325
-533	BORON TO STAINLESS STEEL	0.005 0.005 0.004 0.004	2.000 *	8600 5450 7650 7375	4300 † 2725 3825 3688
				AVG 7290	AVG 3645
-535	S-994 GLASS TO TITANIUM	0.0040 0.0055 0.0040 0.0035 0.0040	2.001 2.070 2.017 2.005 2.002	6375 5175 5260 6560 6415	3185 2500 2605 3270 3200
				AVG 5957	AVG 2952
-537	S-994 GLASS TO TITANIUM	0.0030 0.0025 0.0020 0.0027 0.0035	2.050 2.048 2.038 2.027 2.084	5775 6385 5875 5650 5390	2820 3115 2885 2785 2585
				AVG 5815	AVG 2838
-539	S-994 GLASS TO TITANIUM	0.0040 0.0025 0.0070 0.0045 0.0040	1.978 2.234 2.013 2.019 2.195	6100 5625 5185 5090 6040	3085 2520 2580 2520 2750
				AVG 5608	AVG 2691
-541	S-994 GLASS TO STAINLESS STEEL	0.001 0.001 0.001 0.002 0.001	2.000 *	6650 6150 7225 5525 6275	3325 3075 3612 2763 : 3138
				AVG 6575	AVG 3287
-543	S-994 GLASS TO STAINLESS STEEL	0.002 0.001 0.002 0.001 0.002	2.00 *	6475 6150 5950 6600 7125	3237 3075 2975 3300 3562
				AVG 6460	AVG 3230
-545	S-994 GLASS TO STAINLESS STEEL	0.001 0.001 0.001 0.001 0.001	2.00 *	6400 6300 5925 6575 5975	3200 3150 2962 3287 2987
				AVG 6235	AVG 3115

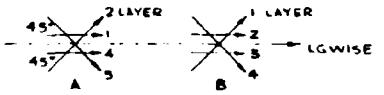
† ADHEREND FAILURE

: OMITTED FROM AVERAGE

* STRESS CALCULATIONS ARE BASED ON NOMINAL SPECIMEN DIMENSIONS.

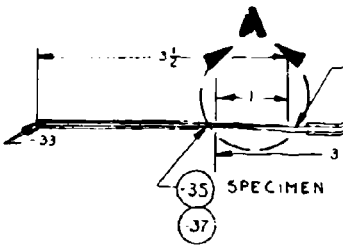
GEN NOTES: UNLESS OTHERWISE STATED

1. IDENTIFY PER DPS 3.02
2. SPECIMEN FAB & PROCESSING METHODS PER DPS 1463-Z3824828
3. BOND WITH SHELL 951 ADHESIVE
4. LAMINATES ARE MADE UP OF MULTIPLES OF THE FOLLOWING PATTERNS:

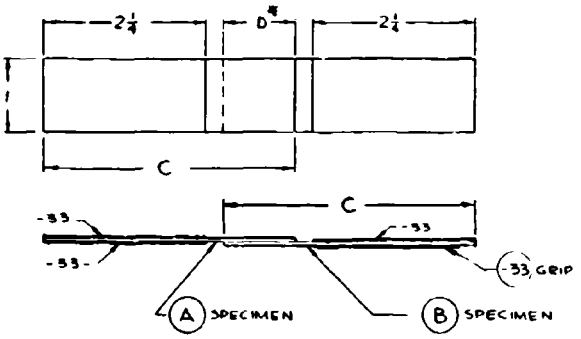


IN EACH CASE LAYER 1 IS THE OUTERMOST LAYER AND LAY-UP IS SYMMETRICAL ABOUT THE MID-PLANE OF THE LAMINATE

5. FIRST ISSUE RELEASE REQUIREMENTS: 5 EA REQ -1 THRU -545
6. * 1 INCH OVERLAP DRAWN
   ½ & 2 INCH OVERLAPS SIMILAR
   SEE TABLE FOR DETAILS OF CONFIGURATIONS



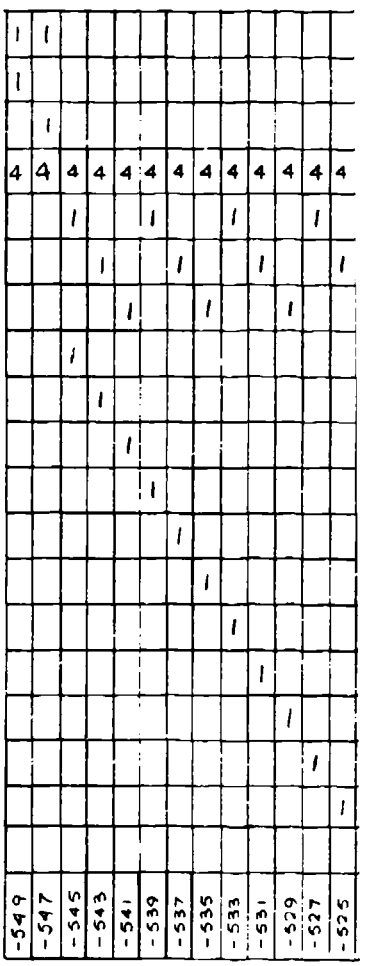
FOR -547 & -549 ONLY



DETAILS OF CONFIGURATIONS

CONFIG-URATION	A	B	C	D
-1	-3	-3	3	½
-501	-5	-5	3½	1
-503	-7	-7	4½	2
-505	-9	-9	3	½
-507	-11	-11	3½	1
-509	-13	-13	4½	2
-511	-15	-15	3	½
-513	-17	-17	3½	1
-515	-19	-19	4½	2
-517	-21	-21	3	½
-519	-25	-25	5½	1
-521	-25	-25	4½	2

CONFIG-URATION	A	B	C	D
-523	-3	-27	3	½
-525	-5	-29	3½	1
-527	-7	-31	4½	2
-529	-9	-27	3	½
-531	-11	-29	3½	1
-533	-13	-31	4½	2
-535	-15	-27	3	½
-537	-17	-29	3½	1
-539	-19	-31	4½	2
-541	-21	-27	3	½
-543	-25	-29	5½	1
-545	-25	-31	4½	2



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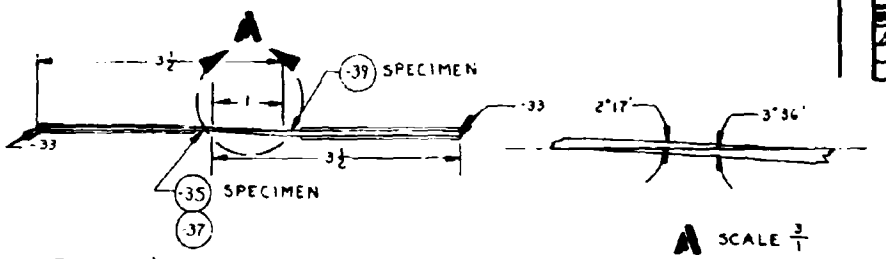


FOR 547 & -549 ONLY

REVISIONS			
DIM	DESCRIPTION	DATE	APPROVED
A	SPECIMEN	4-6-67	[illegible]

-549	-547	-545	-543	-541	-539	-537	-535	-533	-531	-529	-527	-525	-523	-521	-519	-517	-515	-513	-511	-509	-507	-505	-503	-501	-1	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	STOCK SIZE	MATERIAL DESCRIPTION	MATERIAL SPECIFICATION	PROD NO.
	1	1																								-39	SPECIMEN		.063 X 1 X 3½	AL SHEET CLAD 7075 T-6	QQ-A-250/13 TEMP T-6	
1																										-37			.040 X 1 X 3½	PATTERN A 4 LAYERS	S-994 HTS GLASS	
	1																									-35			.040 X 1 X 3½	PATTERN A 8 LAYERS	BORON DMS 1919	
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	-33	GRIP		.032 x 1 x 2½	AL SHEET CLAD 2014 -O	QQ-A-250/4 TEMP-O	
			1			1			1			1														-31	SPECIMEN		.063x 1 x 4½	AL SHEET CLAD 7075 T-6	QQ A 250/13 TEMP T-6	
				1			1			1			1													-29			.063x 1 x 3½			
					1			1			1															-27			.063x 1 x 3			
						1						2														-25			.040x 1 x 4½	PATTERN B 4 LAYERS	S-994 HTS GLASS	
							1						2													-23			.040x 1 x 3½			
								1						2												-21			.040x 1 x 3			
									1						2											-19			.040x 1 x 4½	PATTERN A 4 LAYERS		
										1						2										-17			.040x 1 x 3½			
											1						2									-15			.040x 1 x 3			
												1						2								-13			.040x 1 x 4½	PATTERN B 8 LAYERS	BORON DMS 1919	
													1						2							-11			.040x 1 x 3½			
														1						2						-9			.040x 1 x 3			
															1						2					-7			.040x 1 x 4½	PATTERN A 8 LAYERS		
																1						2				-5			.040x 1 x 3½			
																	1						2		2	-3			.040x 1 x 3			

LIST OF MATERIALS

QUANTITY REQUIRED PER NOTED ASSY

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES FRACTIONS ± 1/32 DECIMALS ± .015 ANGLES ± 1/2°

MATL | WT CHK | STR CHK | CHECK E. SPENCER 4/6/67 | PR ENGR A. LEHMAN 4/6/67 | DES ENGR | QR ENGR | PREP BY HAWLEY 4-21-67

DOUGLAS AIRCRAFT COMPANY, INC. LONG BEACH, CALIFORNIA

SPECIMEN ASSY – SINGLE LAP ADHESIVE JOINT

SEE ENGINEERING RECORDS FOR USAGE DATA

MATERIAL ACTIVITY APPROVAL

CUSTOMER APPROVAL

CODE IDENT NO. 88277 | SIZE D | Z3824828

SCALE 1 | SHEET 1 OF 1

DRAWING Z3824828. SPECIMEN ASSEMBLY – SINGLE LAP ADHESIVE JOINT

B

TABLE V
SINGLE LAP ADHESIVE JOINT STRENGTH SUMMARY
(SHELL 951 ADHESIVE – 1-INCH SPECIMEN WIDTH)

CONFIGURATION Z3824828	SPECIMEN MATERIAL	BOND LINE DATA		ULTIMATE LOAD (LB)	ULTIMATE STRESS (PSI)
		ACTUAL THICKNESS (IN.)	AREA (SQ IN.)		
-1	BORON TO BORON	0.002	0.505	2960	6861
		0.0015	0.502	2855	5687
		0.001	0.515	2875	5582
		0.005	0.507	2850	5621
		0.005	0.507	2985	5887
				AVG 2905	AVG 5722
-501	BORON TO BORON	0.001	1.012	4050	4002*
		0.0007	1.015	3930	3872
		0.001	0.998	3860	3867*
		0.0013	1.025	3920	3824
		0.001	0.990	3780	3818*
JAN 1968				AVG 3908	AVG 3875
-501	BORON TO BORON	0.003	1.029	3478	3380
		0.004	1.012	3400	3360
		0.004	1.013	3485	3440
		0.003	1.009	3328	3300
		0.003	1.012	3238	3200
REPEATED DEC 1968				AVG 3385	AVG 3336
-503	BORON TO BORON	0.0017	1.980	3305	1669*
		0.0032	2.032	4265	2099
		0.002	2.000	4125	2063
		0.0023	2.047	4170	2037
		0.003	2.050	3930	1917*
				AVG 3959	AVG 1957
-505	BORON TO BORON	0.002	0.495	2,390	4,828
		0.0015	0.506	2400	4743
		0.002	0.507	2280	4497
		0.002	0.509	2165	4253
		0.002	0.508	2575	5068
				AVG 2362	AVG 4678
-507	BORON TO BORON	0.002	1.005	3945	3925
		0.002	1.022	4410	4315*
		0.002	1.003	3940	3928
		0.002	0.999	3675	3678
		0.002	1.008	3520	3492
				AVG 3898	AVG 3868
-509	BORON TO BORON	0.002	1.963	4560	2323*
		0.0015	1.992	4520	2269*
		0.002	1.970	3460	1756*
		0.002	1.968	4380	2226*
		0.002	1.965	4125	2099*
				AVG 4209	AVG 2155
-511	S994 GLASS TO S994 GLASS	0.001	0.518	2670	5154
		0.002	0.510	2818	5525
		0.002	0.536	2810	5242
		0.0015	0.531	2655	5000
		0.002	0.507	2290	4516
				AVG 2648	AVG 5087

TABLE V
SINGLE LAP ADHESIVE JOINT STRENGTH SUMMARY (Continued)
(SHELL 951 ADHESIVE – 1-INCH SPECIMEN WIDTH)

CONFIGURATION Z3824828	SPECIMEN MATERIAL	BOND LINE DATA		ULTIMATE LOAD (LB)	ULTIMATE STRESS (PSI)
		ACTUAL THICKNESS (IN.)	AREA (SQ IN.)		
-513	S-994 GLASS TO S994 GLASS	0.001	1.017	3855	3791
		0.001	1.044	3385	3242
		0.001	1.021	3510	3438
		0.002	1.042	3720	3570
		0.002	1.045	3220	3081
				AVG 3538	AVG 3424
-515	S-994 GLASS TO S-994 GLASS	0.002	2.035	3210	1577
		0.002	2.035	3915	1924
		0.002	2.067	3365	1628
		0.002	2.035	3810	1872
		0.002	2.004	3950	1971
				AVG 3650	AVG 1794
-517	S-994 GLASS TO S-994 GLASS	0.001	0.500	1918	3836
		0.001	0.488	2813	6764
		0.001	0.496	2985	6018
		0.001	0.490	3042	6208
		0.001	0.498	1720	3454
				AVG 2496	AVG 5056
-519	S-994 GLASS TO S-994 GLASS	0.001	1.025	3020	2946
		0.001	1.025	3055	2980
		0.001	1.011	2480	2453
		0.001	1.004	2560	2550
		0.001	1.035	2480	2396
				AVG 2719	AVG 2665
-521	S-994 GLASS TO S-994 GLASS	0.001	2.026	4330	2137
		0.0025	2.052	4160	2027
		0.0015	1.940	3560	1835
		0.0025	2.015	4050	2010
		0.002	2.054	2440	1188
				AVG 3708	AVG 1839
-523	BORON TO ALUMINUM	0.0015	0.511	2410	4716
		0.002	0.512	2620	5117
		0.002	0.508	2310	4547
		0.002	0.502	2310	4601
		0.002	0.516	2430	4709
				AVG 2416	AVG 4738
-525 JAN 1968	BORON TO ALUMINUM	0.0019	1.024	2040	1992
		0.002	1.018	2200	2161
		0.0015	1.014	3350	3304
		0.002	1.005	2560	2547
		0.002	1.007	2420	2403
				AVG 2514	AVG 2480
-525 REPEATED DEC 1968	BORON TO ALUMINUM	0.003	0.992	3235	3260
		0.004	1.009	3490	3460
		0.003	1.000	3280	3280
		0.002	1.040	2830	3720
		0.003	1.003	2368	2360
				AVG 3040	AVG 3016

TABLE V
SINGLE LAP ADHESIVE JOINT STRENGTH SUMMARY (Continued)
(SHELL 951 ADHESIVE – 1-INCH SPECIMEN WIDTH)

CONFIGURATION Z3824828	SPECIMEN MATERIAL	BOND LINE DATA		ULTIMATE LOAD (LB)	ULTIMATE STRESS (PSI)
		ACTUAL THICKNESS (IN.)	AREA (SQ IN.)		
-527	BORON TO ALUMINUM	0.002	1.995	3510	1759
		0.002	1.995	4220	2116
		0.002	2.010	3780	1881
		0.002	2.014	4020	1996
		0.002	2.000	2820	1410
				AVG 3670	AVG 1832
-529	BORON TO ALUMINUM	0.0010	0.620	2155	3476
		0.0017	0.572	2135	3733
		0.0019	0.578	2175	3763
		0.0010	0.530	1485	2802
		0.0011	0.514	2095	4076
				AVG 2009	AVG 3570
-531	BORON TO ALUMINUM	0.0025	1.005	3805	3786
		0.002	1.000	4080	4080
		0.0025	1.005	3840	3821
		0.002	1.006	3390	3370
		0.002	1.025	3110	3036
				AVG 3645	AVG 3630
-533	BORON TO ALUMINUM	0.002	1.965	3460	1760*
		0.0015	1.966	3410	1734*
		0.002	1.96b	3930	1998*
		0.002	1.955	4200	2148**
		0.002	1.950	3900	2000**
				AVG 3780	AVG 1928
-535	S-994 GLASS TO ALUMINUM	0.002	0.502	2180	4343
		0.002	0.503	2120	4215
		0.002	0.507	1815	3580
		0.001	0.517	1803	3487
		0.001	0.508	2115	4163
				AVG 2006	AVG 3958
-537	S-994 GLASS TO ALUMINUM	0.003	1.033	1850	1791
		0.003	1.042	3100	2975
		0.003	1.035	1960	1894
		0.003	1.039	2540	2445
		0.003	1.050	2140	2038
				AVG 2318	AVG 2229
-539	S-994 GLASS TO ALUMINUM	0.003	2.000	2240	1120
		0.002	2.010	2480	1234
		0.002	2.015	2610	1295
		0.003	2.010	2715	1351
		0.003	2.008	2270	1130
				AVG 2463	AVG 1226
-541	S-994 GLASS TO ALUMINUM	0.004	0.520	1642	3157
		0.003	0.520	2413	4640
		0.003	0.516	1875	3633
		0.003	0.519	2187	4213
		0.004	0.512	2487	4857
				AVG 2121	AVG 4100

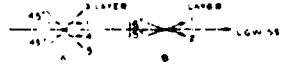
TABLE V
SINGLE LAP ADHESIVE JOINT STRENGTH SUMMARY (Concluded)
(SHELL 951 ADHESIVE – 1-INCH SPECIMEN WIDTH)

CONFIGURATION Z3824828	SPECIMEN MATERIAL	BOND LINE DATA		ULTIMATE LOAD (LB)	ULTIMATE STRESS (PSI)
		ACTUAL THICKNESS (IN.)	AREA (SQ IN.)		
-543	S-994 GLASS TO ALUMINUM	0.003 0.003 0.003 0.003 0.003	0.969 0.985 0.987 0.977 1.011	2080 2983 2732 2605 2365	2146 3028 2767 2666 2339
				AVG 2553	AVG 2589
-545	S-994 GLASS TO ALUMINUM	0.002 0.0025 0.002 0.002 0.0025	1.970 1.998 1.977 1.985 1.979	2280 3335 3330 3345 3180	1157 1668 1684 1685 1607
				AVG 3094	AVG 1560
-547	BORON TO ALUMINUM	0.005 0.004 0.005 0.003 0.010	1.045 1.040 1.023 1.053 1.034	2905 3000 2580 2600 2820	2780 2885 2522 2469 2727
				AVG 2781	AVG 2677
-549 EXTERNAL SCARF	S-994 GLASS TO ALUMINUM	0.003 0.002 0.004 0.005	1.046 1.015 1.035 1.037	2690 2320 1650 2875	2572 2285 1594 2772
				AVG 2383	AVG 2306

*BORON DELAMINATED
**FAILED THROUGH COMPOSITE SECTION

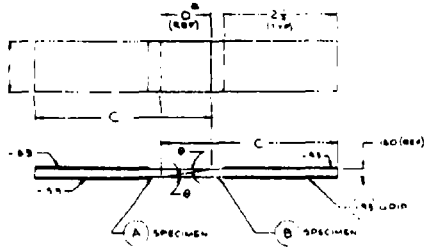
GEN NOTES: UNLESS OTHERWISE STATED

1. IDENTIFY PER DPS 9.02
2. SPECIMEN FAB & PROCESSING METHODS PER DPS 1445-B & 3824829
3. BOND WITH SHELL 951 ADHESIVE (EXCEPT -561)
4. LAMINATES ARE MADE UP OF MULTIPLES OF THE FOLLOWING PATTERNS



A

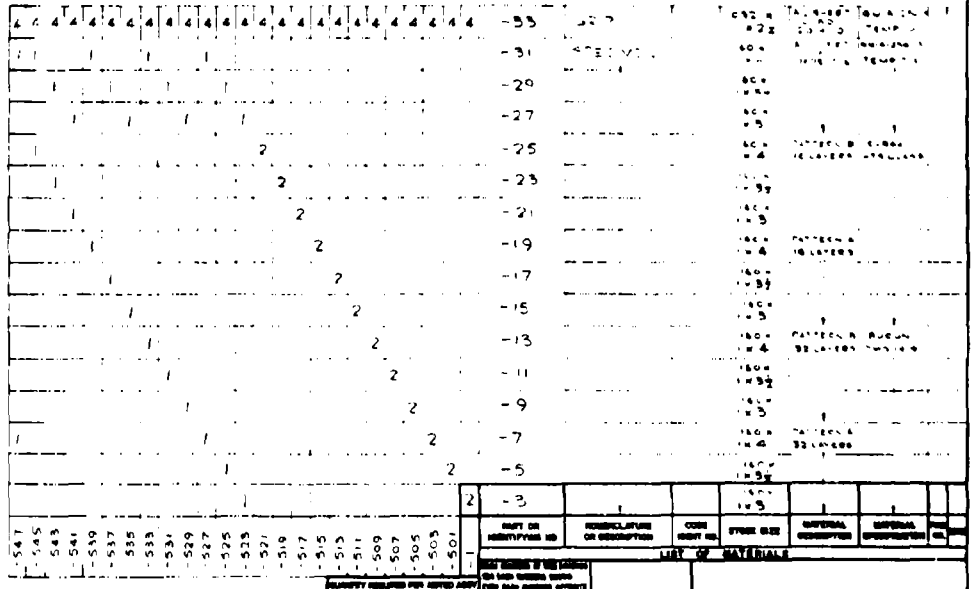
5. EXCEPT AS LAYED UP IS THE OUTERMOST LAYER AND LAY-UP IS SYMMETRICAL ABOUT THE MID PLANE OF THE LAMINATE
6. FIRST ISSUE RELEASE REQUIREMENTS
7. FA REQ -11 THRU -14 SB
8. B - .10 INCH OVERLAP DRAWN
9. B (.1) INCH OVERLAPS SIMILAR
10. SEE TABLE FOR DETAILS OF CONFIGURATIONS
11. ALTERNATIVE AL SHEET MATERIAL MAY BE SUBSTITUTED FOR 9014.0 FOR -55 GRIP
12. BOND -561 WITH EA 9628 ADHESIVE



DETAILS OF CONFIGURATIONS

CONFIGURATION	A	B	C	D (REF)	θ ±.10°
-501	-5	-5	3	1/2	17°45'
-503	-5	-5	5 1/2	1	9°05'
-505	-7	-7	4	1 1/2	6°05'
-507	-9	-9	3	1/2	17°45'
-509	-11	-11	5 1/2	1	9°05'
-511	-13	-13	4	1 1/2	6°05'
-513	-15	-15	3	1/2	17°45'
-515	-17	-17	5 1/2	1	9°05'
-517	-19	-19	4	1 1/2	6°05'
-519	-21	-21	3	1/2	17°45'
-521	-23	-23	5 1/2	1	9°05'
	-25	-25	4	1 1/2	6°05'

CONFIGURATION	A	B	C	D (REF)	θ ±.10°
-525	-5	-27	3	1/2	17°45'
-525	-5	-29	5 1/2	1	9°05'
-527	-7	-31	4	1 1/2	6°05'
-529	-9	-27	3	1/2	17°45'
-531	-11	-29	5 1/2	1	9°05'
-535	-13	-31	4	1 1/2	6°05'
-535	-18	-27	3	1/2	17°45'
-537	-17	-29	5 1/2	1	9°05'
-539	-19	-31	4	1 1/2	6°05'
-541	-21	-27	3	1/2	17°45'
-545	-23	-29	5 1/2	1	9°05'
-545	-25	-31	4	1 1/2	6°05'
-547	7	-31	4	1 1/2	6°05'



LIST OF MATERIALS

DOUGLAS — LONG BEACH, CALIFORNIA

SPECIMEN ASSY - SCARF ADHESIVE JOINT

88277 D Z3824829

DRAWING Z3824829. SPECIMEN ASSEMBLY – SCARF ADHESIVE JOINT

TABLE VI
SCARF ADHESIVE JOINT STRENGTH SUMMARY
(SHELL 951 ADHESIVE – 1-INCH SPECIMEN WIDTH)

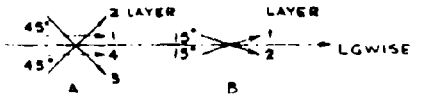
CONFIGURATION Z3824829	SPECIMEN MATERIAL	BOND LINE DATA		ULTIMATE LOAD (LB)	ULTIMATE STRESS (PSI)
		ACTUAL THICKNESS (IN.)	AREA (SQ IN.)		
-1	BORON	0.006	0.520	2130	4095
		0.005	0.505	2500	4950
		0.008	0.505	1780	3525
				AVG 2137	AVG 4190
-501	BORON	0.002	1.040	5590	5375
		0.004	1.025	4630	4515
		0.002	1.010	5480	5425
				AVG 5233	AVG 5105
-503	BORON	0.005	1.510	7615	5045
		0.005	1.493	7750	5190
		0.005	1.500	7640	5095
				AVG 7672	AVG 5110
-505	BORON	0.003	0.544	1475	2710
		0.009	0.543	1260	2320
		0.005	0.545	1690	3100
				AVG 1475	AVG 2705
507	BORON	0.002	1.040	4040	3885
		0.006	1.050	3130	2980
		0.009	1.030	3060	2970
				AVG 3410	AVG 3275
-509	BORON	0.004	1.505	6250	4150
		0.008	1.495	6350	4250
		0.007	1.510	6975	4620
				AVG 6525	AVG 4335
511	S-994 GLASS	0.014	0.559	1530	2735
		0.013	0.530	1840	3470
		0.013	0.553	2780	5030
				AVG 2050	AVG 3745
-513	S-994 GLASS	0.0085	1.123	5950	5300
		0.0080	1.061	5550	5230
		0.0085	1.038	5275	5080
				AVG 5592	AVG 5205
-515	S-994 GLASS	0.008	1.755	9600	5470
		0.010	1.682	9035	5370
		0.008	1.720	10,060	5850
				AVG 9565	AVG 5560
-517	S-994 GLASS	0.012	0.569	2825	4965
		0.014	0.531	1790	3370
		0.011	0.564	2710	4805
				AVG 2442	AVG 4375
519	S-994 GLASS	0.012	1.113	4500	4045
		0.012	1.068	6200	5805
		0.013	1.091	5675	5200
				AVG 5458	AVG 5010
-521	S-994 GLASS	0.009	1.668	8925	5350
		0.009	1.775	10,010	5640
		0.008	1.655	9675	5850
				AVG 9537	AVG 5610
523	BORON/ALUMINUM	0.006	0.480	1730	3605
		0.006	0.505	1500	2970
		0.008	0.505	1835	3635
				AVG 1688	AVG 3400

TABLE VI
SCARF ADHESIVE JOINT STRENGTH SUMMARY (Concluded)
(SHELL 951 ADHESIVE – 1-INCH SPECIMEN WIDTH)

CONFIGURATION Z3824829	SPECIMEN MATERIAL	BOND LINE DATA		ULTIMATE LOAD (LB)	ULTIMATE STRESS (PSI)
		ACTUAL THICKNESS (IN.)	AREA (SQ IN.)		
-525	BORON/ALUMINUM	0.004	0.950	5030	5295
		0.007	0.969	4550	4695
		0.008	0.932	4470	4795
				AVG 4683	AVG 4930
-527	BORON/ALUMINUM	0.004	1.435	7315	5100
		0.005	1.425	6900	4840
		0.007	1.445	6675	4620
				AVG 6963	AVG 4855
-529	BORON/ALUMINUM	0.005		FAILED PRIOR TO TEST	
		0.010	0.510	1880	3685
		0.008	0.475	675	1420
				AVG 1277	AVG 2550
531	BORON ALUMINUM	0.006	0.975	5500	5640
		0.005	0.975	5360	5495
		0.005	0.965	3770	3910
				AVG 4877	AVG 5015
-533	BORON/ALUMINUM	0.007	1.425	7350	5160
		0.008	1.450	6185	4265
		0.007	1.435	6350	4425
				AVG 6628	AVG 4610
535	S 994 GLASS/ ALUMINUM	0.006	0.547	2595	4745
		0.007	0.545	2255	4140
		0.006	0.545	2990	5485
				AVG 2613	AVG 4790
-537	S-994 GLASS/ ALUMINUM	0.006	1.150	5620	4885
		0.004	1.100	5400	4910
		0.009	1.018	5370	5255
				AVG 5463	AVG 5020
-539	S-994 GLASS/ ALUMINUM	0.008	1.515	6625	4376
		0.008	1.695	6650	3925
		0.009	1.500	7150	4765
				AVG 6808	AVG 4355
541	S-994 GLASS/ ALUMINUM	0.005	0.518	2630	5075
		0.004	0.543	2860	5265
		0.004	0.536	2940	5485
				AVG 2810	AVG 5275
-543	S-994 GLASS/ ALUMINUM	0.006	1.010	5880	5820
		0.002	1.120	5475	4890
		0.003	1.110	6275	5655
				AVG 5877	AVG 5455
-545	S-994 GLASS/ ALUMINUM	0.004	1.525	8475	5560
		0.005	1.531	7800	5095
		0.003	1.550	7975	5145
				AVG 8083	AVG 5265
-547	BORON/ALUMINUM AF 130 ADHESIVE	0.003	1.480	8560	5780
		0.003	1.484	9050	6100
		0.003	1.480	7980	5390
				AVG 8530	AVG 5758

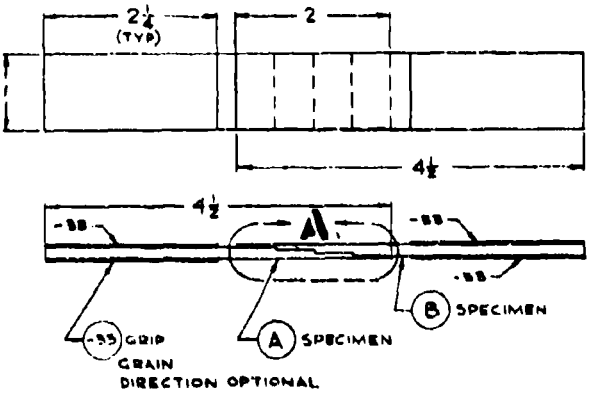
GEN NOTES: UNLESS OTHERWISE STATED

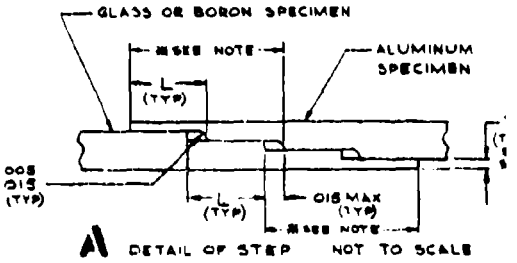
1. IDENTIFY PER DPS 3.02
2. SPECIMEN FAB & PROCESSING METHODS PER DPS 1.465-8924850
3. BOND WITH SHELL 951 ADHESIVE
4. LAMINATES ARE MADE UP OF MULTIPLES OF THE FOLLOWING PATTERNS:



IN EACH CASE LAYER 1 IS THE OUTERMOST LAYER AND LAY-UP IS SYMMETRICAL ABOUT THE MID-PLANE OF THE LAMINATE

5. FIRST ISSUE RELEASE REQUIREMENTS: 5 EA REQ: -1 THRU -521
6. ALTERNATIVE AL SHEET MATERIAL MAY BE SUBSTITUTED FOR 2014-O FOR -55 GRIP





A DETAIL OF STEP NOT TO SCALE

4-STEP JOINT SHOWN
2 & 8-STEP JOINTS SIMILAR
SEE TABLE FOR DETAILS OF L & T

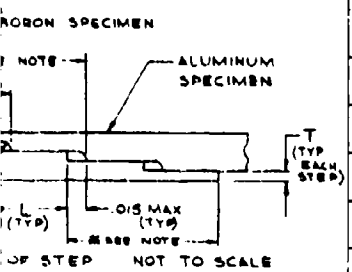
* ±.010 TOLERANCE ON CUMULATIVE LENGTHS OF L

DETAILS OF CONFIGURATIONS

CONFIGURATION	A	B	NO. OF STEPS	L *	T ±.005
-1	-5	-27	2	1.000	.080
-501	-5	-29	4	0.500	.040
-505	-7	-31	8	0.250	.020
-503	-9	-27	2	1.000	.080
-507	-11	-29	4	0.500	.040
-509	-13	-31	8	0.250	.020
-511	-15	-27	2	1.000	.080
-513	-17	-29	4	0.500	.040
-515	-19	-31	8	0.250	.020
-517	-21	-27	2	1.000	.080
-519	-23	-29	4	0.500	.040
-521	-25	-31	8	0.250	.020

A

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED
A	SEE EO		



QUANTITY REQUIRED PER NOTED ASSY	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	STOCK SIZE	MATERIAL DESCRIPTION	MATERIAL SPECIFICATION	PROD NO.	NOTE
4	-33	GRIP		.032 x 1 x 24	AL SHEET CLAD 2014-O	QQ-A-250/5 TEMP-O		
1	-31	SPECIMEN		.160 x 1 x 4½	AL SHEET CLAD 7075 T-6	QQ-A-250/13 TEMP T-6		
1	-29			.160 x 1 x 4½				
1	-27			.160 x 1 x 4½				
1	-25			.160 x 1 x 8½	PATTERN B 16 LAYERS	S-994 HTS GLASS		
1	-23			.160 x 1 x 4½				
1	-21			.160 x 1 x 4½				
1	-19			.160 x 1 x 4½	PATTERN A 16 LAYERS			
1	-17			.160 x 1 x 4½				
1	-15			.160 x 1 x 4½				
1	-13			.160 x 1 x 4½	PATTERN B 32 LAYERS	BORON DMS 1919		
1	-11			.160 x 1 x 4½				
1	-9			.160 x 1 x 4½				
1	-7			.160 x 1 x 4½	PATTERN A 32 LAYERS			
1	-5			.160 x 1 x 4½				
1	-3			.160 x 1 x 4½				
1	-1							

LIST OF MATERIALS

DASH NUMBERS OF THIS DRAWING
OTHER DASH NUMBERS SHOWN
OTHER DASH NUMBERS OPPOSITE

FINISH

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES.
TOLERANCES
FRACTIONS ± 1/64
DECIMALS ± .015
ANGLES ± 1/2°

MATL		
WT CHK		
STR CHK		
CHECK		
PR ENGR	[illegible]	9/5/67
DES ENGR	[illegible]	
GR ENGR		
PREP BY	HAWLEY	9-21-67

DOUGLAS AIRCRAFT COMPANY, INC LONG BEACH, CALIFORNIA

SPECIMEN ASSY – STEPPED LAP ADHESIVE JOINT

SEE ENGINEERING RECORDS FOR USAGE DATA

FIRST RELEASE DATE OCT 23 1967
ORIGINAL DATE OF DRAWING OCT 2 1967

DESIGN ACTIVITY APPROVAL
CUSTOMER APPROVAL

CODE IDENT NO 88277 | SIZE D | Z3824830

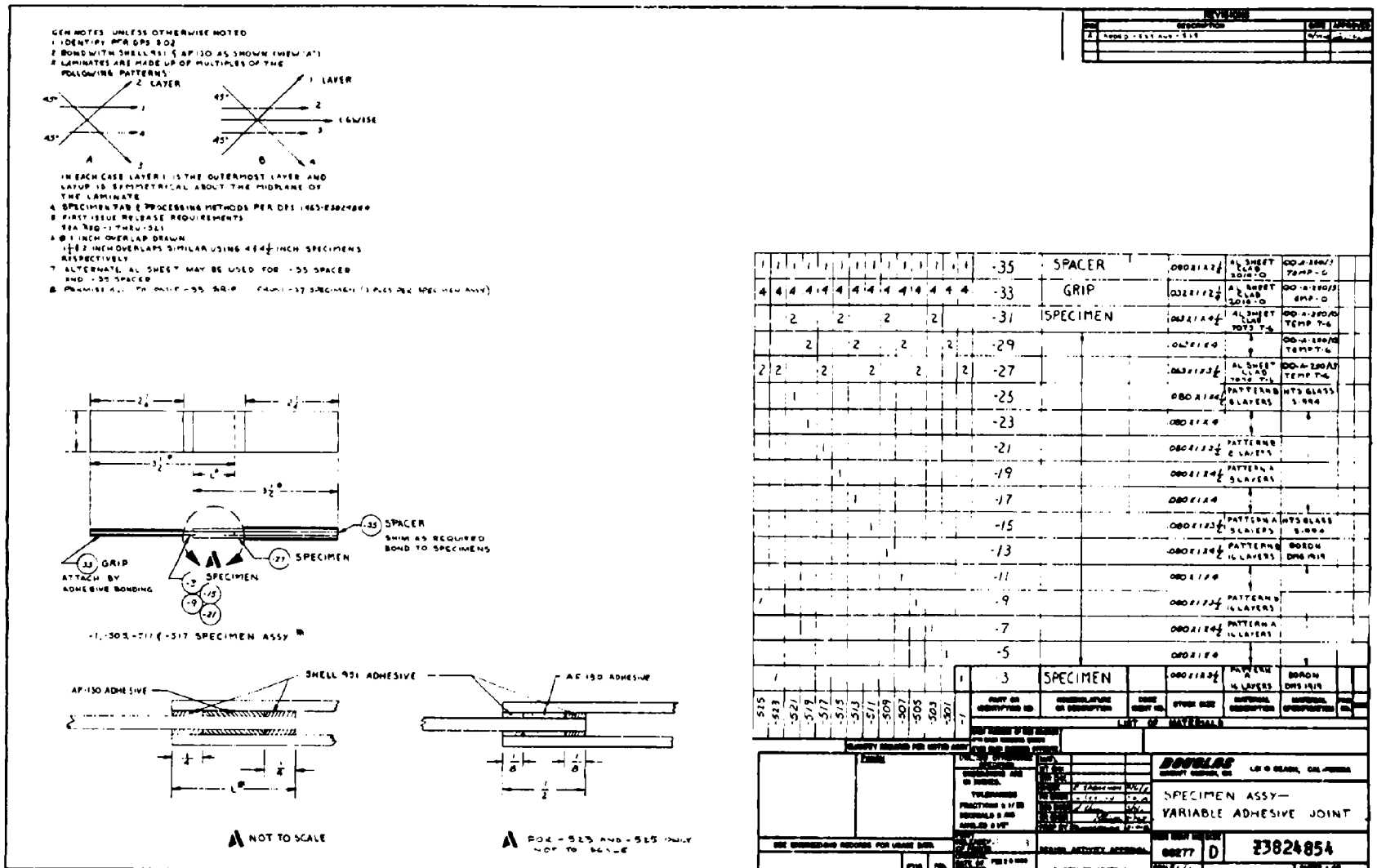
SCALE 1 (NOTED) | SHEET 1 OF 1

DRAWING Z3824830. SPECIMEN ASSEMBLY – STEPPED LAP ADHESIVE JOINT

B

TABLE VII
STEPPED LAP ADHESIVE JOINT STRENGTH SUMMARY
(SHELL 951 ADHESIVE – 1-INCH SPECIMEN WIDTH)

CONFIGURATION Z3824830	SPECIMEN MATERIAL	BOND LINE DATA		ULTIMATE LOAD (LB)	ULTIMATE STRESS (PSI)
		ACTUAL THICKNESS (IN.)	AREA (SQ IN.)		
1	BORON/ALUMINUM	0.002	1.985	9350	4734
		0.002	1.975	9675	4899
		0.003	1.995	11,725	5877
		0.002	1.975	11,875	6013
		0.003	1.990	11,775	5917
				AVG 10,880	AVG 5488
-501	BORON/ALUMINUM	0.003	1.965	11,776	5992
		0.002	1.982	11,905	6007
		0.002	1.980	11,990	6056
		0.003	1.977	11,825	5981
		0.004	1.963	11,875	6049
				AVG 11,874	AVG 6017
-503	BORON/ALUMINUM	0.003	1.978	11,335	5730
		0.003	1.975	11,385	5764
		0.002	1.978	11,640	5884
		0.002	1.965	11,260	5730
		0.002	1.969	11,275	5726
				AVG 11,379	AVG 5767
-505	BORON/ALUMINUM	0.003	1.977	11,845	5991
		0.002	1.984	10,130	5105
		0.003	1.989	11,175	5618
		0.002	1.975	11,700	5824
		0.002	1.974	10,415	5276
				AVG 11,053	AVG 5583
-507	BORON/ALUMINUM	0.003	1.975	11,950	6050
		0.003	1.979	11,000	5558
		0.002	1.977	11,825	5981
		0.002	1.948	11,585	5947
		0.003	1.973	11,990	6077
				AVG 11,870	AVG 5925
-509	BORON/ALUMINUM	0.003	1.968	11,600	5891
		0.002	1.965	11,625	5916
		0.002	1.963	11,700	5960
		0.003	1.958	11,200	5720
		0.003	1.965	11,675	5911
				AVG 11,560	AVG 5880
-511	GLASS/ALUMINUM	0.004	1.979	8270	4179
		0.003	1.975	7025	3557
		0.004	1.983	7365	3747
		0.003	1.968	7400	3760
		0.003	1.979	6880	3476
				AVG 7386	AVG 3744
-513	GLASS/ALUMINUM	0.003	1.968	9775	4967
		0.004	1.971	8525	4326
		0.003	1.975	8675	4392
		0.004	1.965	8325	4236
		0.004	1.975	8850	4481
				AVG 8830	AVG 4480
-515	GLASS/ALUMINUM	0.003	1.989	7040	3575
		0.003	1.974	6860	3470
		0.002	1.970	7150	3629
		0.003	1.981	7120	3604
		0.004	1.970	6700	3401
				AVG 6972	AVG 3534
-517	GLASS/ALUMINUM	0.004	1.988	9650	4854
		0.004	1.976	8500	4303
		0.003	1.966	9800	4984
		0.003	1.964	8725	4442
		0.003	1.962	8685	4375
				AVG 9052	AVG 4592
-519	GLASS/ALUMINUM	0.003			
		0.004		8350	
		0.004	1.965	8025	4084
		0.003	1.972	7225	3663
		0.003	1.983	8800	4438
				AVG 8100	AVG 4037
-521	GLASS/ALUMINUM	0.004	1.975	6925	3506
		0.004	1.953	5700	2918
		0.003	1.975	6675	3379
		0.004	1.965	7100	3613
		0.004	1.980	7650	3903
				AVG 6810	AVG 3772



DRAWING Z3824854. SPECIMEN ASSEMBLY – VARIABLE ADHESIVE JOINT

TABLE VIII
VARIABLE STIFFNESS ADHESIVE JOINT STRENGTH SUMMARY
(SHELL 951 AND AF130 ADHESIVES, 1-INCH SPECIMEN WIDTH)

CONFIGURATION Z3824854	SPECIMEN MATERIAL	BOND LINE DATA		ULTIMATE LOAD (LB)	ULTIMATE STRESS (PSI)
		ACTUAL THICKNESS (IN.)	AREA (SQ IN.)		
-1 1.0-IN. LAP	BORON/ALUMINUM	0.005 0.006 0.005 0.005 0.005	2.000 *	6275 7775 7100 6950 8050	3140 3890 3550 3470 4025
JUNE 1968				AVG 7230	AVG 3615
-1 REPEATED	BORON/ALUMINUM	0.003 0.0025 0.004 0.0035 0.004	1.995 — 2.008 1.960 1.952	7175 9350(1) 9160 8745 8860	3570 4700 4580 4460 4550
DEC 1968				AVG 8658	AVG 4372
-501 1.5-IN. LAP	BORON/ALUMINUM	0.005 0.004 0.004 0.005 0.004	3.000 *	6350 7525 6800 7850 7950	2120 2508 2257 2620 2650
				AVG 7297	AVG 2433
-503 2.0-IN. LAP	BORON/ALUMINUM	0.006 0.004 0.006 0.004 0.006	4.000 *	6165 7675 8050 7850 8175	1540 1920 2010 1960 2040
				AVG 7583	AVG 1894
-505 1.0-IN. LAP	BORON/ALUMINUM	0.003 0.005 0.004 0.005 0.004	2.000 *	7775 9650 9325 8725 9800	3890 4825 4660 4360 4900
JUNE 1968				AVG 9055	AVG 4527
-505 REPEATED DEC 1968	BORON/ALUMINUM	0.002 0.0025 0.002 0.002 0.002	1.961 1.953 1.962 — 1.950	9175 9075 9200 9460(1) 8585	4670 4650 4700 4800 4380
				AVG 9100	AVG 4640
-507 1.5-IN. LAP	BORON/ALUMINUM	0.004 0.004 0.004 0.004 0.005	3.000 *	8080 9735 7775 8875 9075	2767 3250 2600 2960 3025
				AVG 8708	AVG 2920
-509 2.0-IN. LAP	BORON/ALUMINUM	0.004 0.004 0.005 0.004 0.004	4.000 *	4,950 4,950 10,300 6,175 10,100	1240 1240 2570 1540 2520
				AVG 7,295	AVG 1820
-511 1.0-IN. LAP	GLASS/ALUMINUM	0.006 0.007 0.008 0.007 0.007	2.046 2.160 2.080 2.057 2.162	3525 5250 5525 5125 4800	1721 2428 2654 2490 2220
				AVG 4845	AVG 2303
-513 1.5-IN. LAP	GLASS/ALUMINUM	0.006 0.006 0.007 0.005 0.006	3.051 3.025 3.051 3.075 3.065	4790 4475 5085 4650 4825	1570 1480 1667 1512 1574
				AVG 4765	AVG 1561

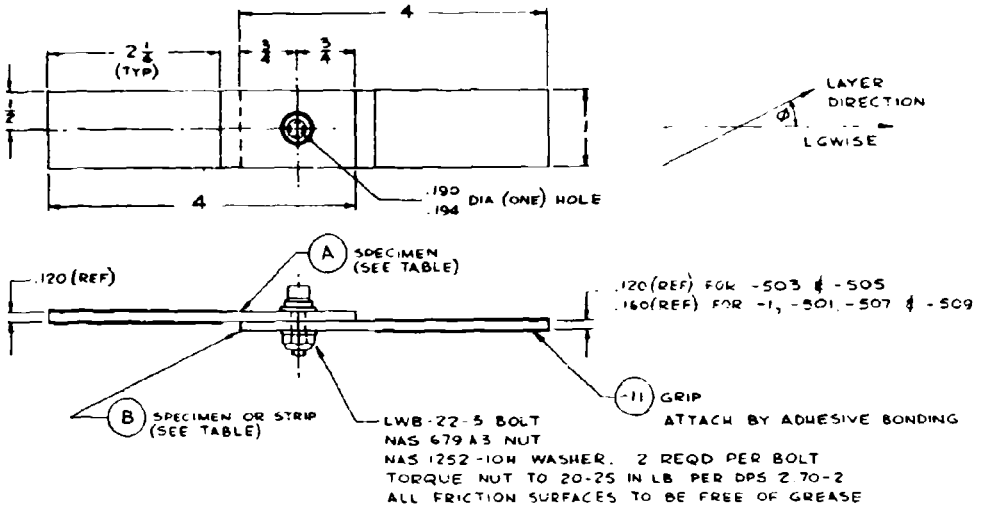
(1)BORON ADHEREND FAILURE

*STRESS CALCULATIONS ARE BASED ON NOMINAL SPECIMEN DIMENSIONS.

TABLE VIII
VARIABLE STIFFNESS ADHESIVE JOINT STRENGTH SUMMARY (Continued)
(SHELL 951 AND AF130 ADHESIVES, 1 INCH SPECIMEN WIDTH)

CONFIGURATION Z3824854	SPECIMEN MATERIAL	BOND LINE DATA		ULTIMATE LOAD (LB)	ULTIMATE STRESS (PSI)
		ACTUAL THICKNESS (IN.)	AREA (SQ IN.)		
-515	GLASS/ALUMINUM	0.006	3.953	4375	1106
		0.006	3.995	5250	1313
2.0-IN. LAP		0.007	4.015	5350	1331
		0.005	4.040	5200	1287
		0.006	4.050	5250	1296
				AVG 5085	AVG 1267
-517	GLASS/ALUMINUM	0.006	2.018	2700	1338
		0.006	2.022	2735	1351
1.0-IN. LAP		0.007	2.038	3300	1620
		0.006	2.073	3150	1520
		0.007	2.020	3250	1610
				AVG 3027	AVG 1488
-519	GLASS/ALUMINUM	0.005	3.010	3175	1054
		0.007	3.020	2600	861
1.5-IN. LAP		0.004	2.980	3325	1116
		0.006	2.995	3225	1077
		0.006	3.055	2785	912
				AVG 3022	AVG 1004
-521	GLASS/ALUMINUM	0.004	4.040	3275	811
		0.007	3.970	3540	892
2.0-IN. LAP		0.006	3.900	3275	840
		0.005	3.995	2875	719
		0.006	4.103	2700	658
				AVG 3133	AVG 784
-523	BORON/ALUMINUM	0.0025	1.020	5335	5230
		0.0035	1.015	4830	4755
0.5-IN. LAP		0.003	1.033	5270	5100
		0.0035	1.038	6000	5780
		0.0035	1.023	3050*	2980*
				AVG 5360	AVG 5215
-525	BORON/ALUMINUM	0.0025	1.028	6300	6130
		0.002	1.038	2875*	2770*
0.5-IN. LAP		0.0025	1.055	5730	5425
		0.002	1.036	5250	5065
		0.002	1.040	3785	3640
				AVG 5254	AVG 5065

*OMITTED FROM AVERAGE



DETAILS OF CONFIGURATIONS

CONFIG-URATION	A	B
-1	-3	-13
-501	-5	-13
-503	-3	-3
-505	-5	-5
-507	-7	-13
-509	-9	-13

DETAILS OF SPECIMENS

DASH NO	FIBER MAT'L	NO. OF LAYERS	NOMINAL THICKNESS
-3	S 994 N.S GLASS	12	.120
-5	BORON DMS 1918	24	.120
-7	IDENTICAL TO -5 EXCEPT FOR THE ADDITION OF *		
-9	IDENTICAL TO -7 EXCEPT FOR LAYER PATTERN		

* DETAILS OF WHISKERS TO BE DETERMINED FOR -7 & -9 PARTS

LAYUP OF SPECIMENS

LAYER	LAYUP ANGLE ϕ°			
	-3	-5	-7	-9
1	0	0	0	45
2	45	45	45	-45
3	-45	-45	-45	45
4	0	0	0	-45
5	0	0	0	0
6	45	45	45	0
7	-45	-45	-45	0
8	0	0	0	0
9	0	0	0	0
10	-45	45	45	0
11	45	-45	-45	0
12	0	0	0	0
13		0	0	0
14		-45	-45	0
15		45	45	0
16		0	0	0
17		0	0	0
18		-45	-45	0
19		45	45	0
20		0	0	0
21		0	0	-45
22		-45	-45	45
23		45	45	-45
24		0	0	45

A

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

AYER
DIRECTION

WISE

-505
-507 & -509

SIVE BONDING

2
ASE

GEN NOTES: UNLESS OTHERWISE NOTED

1. IDENTIFY PER DPS 3.02
2. SPECIMEN FABRICATION & PROCESSING METHODS TO BE PER DPS 1.465-Z3824831
3. USE TABLE BELOW LEFT FOR DETAILS OF SPECIMENS
4. FIRST ISSUE RELEASE REQUIREMENTS: 5 EA REQ -1 THRU -509

-509	-507	-505	-503	-501	-1	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	STOCK SIZE	MATERIAL DESCRIPTION	MATERIAL SPECIFICATION	PROD NO.	REMARKS
2	2	2	2	2	2	NAS 1252 -10H	WASHER						
1	1	1	1	1	1	NAS 679A3	NUT						
		1	1			LWB-22-3-5	BOLT						
1	1			1	1	LWB-22-3-6	BOLT						
1	1			1	1	-13	STRIP		.160 x 1 x 4	AL SHEET CLAD 7075 T-6	QQ-A-250/13 TEMP T-6		
4	4	4	4	4	4	-11	GRIP		.032 x 1 x 2¼	AL SHEET CLAD 2014-0	QQ-A-250/3 TEMP-0		
1						-9	SPECIMEN		.120 x 1 x 4	SEE SPECIMEN TABLE			
	1					-7			.120 x 1 x 4				
		2		1		-5			.120 x 1 x 4				
			2		1	-3			.120 x 1 x 4				

LIST OF MATERIALS

QUANTITY REQUIRED PER NOTED ASSY

S.O. 1621/301

FINISH

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES.
TOLERANCES
FRACTIONS ± 1/32
DECIMALS ± .010
ANGLES ± 1/2°

MATL		
WT CHK		
STR CHK		
CHECK	E. Stevenson	11-7-67
PR ENGR		
DES ENGR		
QR ENGR		
PROJ ENGR	HAWLEY	11-7-67

DOUGLAS AIRCRAFT COMPANY, INC. LONG BEACH, CALIFORNIA

SPECIMEN ASSY — SINGLE LAP BOLTED JOINT

SEE ENGINEERING RECORDS FOR USAGE DATA

PRINT RELEASE OF ENGR CHANGE

DATE OF BUY 3-(68)

DESIGN ACTIVITY APPROVAL

CUSTOMER APPROVAL

CODE IDENT NO. 88277 | SIZE D | Z3824831

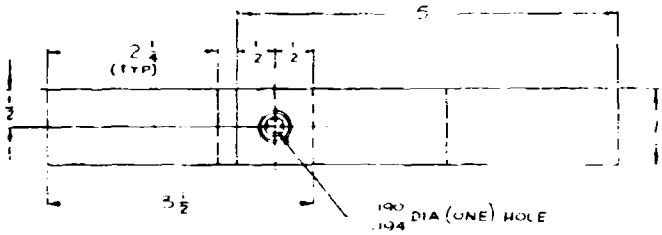
SCALE 1/1 | SHEET 1 OF 1

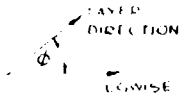
DRAWING Z3824831. SPECIMEN ASSEMBLY – SINGLE LAP BOLTED JOINT

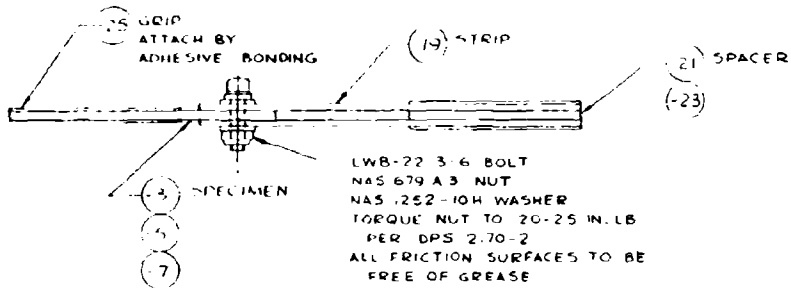
B

TABLE IX
SINGLE LAP BOLTED JOINT STRENGTH SUMMARY
(0.190-INCH BOLT DIAMETER – 1-INCH SPECIMEN WIDTH)

CONFIGURATION Z3824831	LAMINATE THICKNESS (IN.)	LAMINATE WIDTH (IN.)	ULTIMATE LOAD (LB)	STRESSES AT FAILURE (PSI)		
				BEARING	SHEAR-OUT	TENSION THROUGH HOLE
-1 GLASS TO ALUMINUM	0.1102	1.0015	2350	112,200	14,220	26,300
	0.1152	1.0037	2700	123,300	15,630	28,800
	0.1142	1.0119	2535	116,800	14,800	27,050
	0.1135	1.0103	2510	116,300	14,750	27,300
	0.1012	1.0000	2520	131,300	16,600	30,700
			AVG 2523	AVG 119,920	AVG 15,200	AVG 28,030
-501 BORON TO ALUMINUM	0.1171	1.0040	2885	129,800	16,430	30,300
	0.1171	1.0034	2730	123,700	15,550	28,400
	0.1151	1.0202	2980	136,200	17,260	31,200
	0.1168	1.0028	2820	127,000	16,110	29,700
	0.1166	1.0023	2700	122,000	15,440	28,550
			AVG 2823	AVG 127,740	AVG 16,160	AVG 29,640
-503 GLASS TO GLASS	0.1135	0.9678	2085	96,600	12,250	23,600
	0.1163	0.9663	2075	93,900	11,900	23,000
	0.1012	0.9968	2100	109,100	13,840	25,700
	0.1166	1.0002	2190	99,000	12,520	23,200
	0.1136	0.9710	1985	92,000	11,650	22,400
			AVG 2087	AVG 98,120	AVG 12,430	AVG 23,580
-505 BORON TO BORON	0.1160	1.0030	2450	111,200	14,080	26,000
	0.1162	1.0052	2760	125,000	15,840	29,200
	0.1175	0.9941	2490	111,600	14,130	26,350
	0.1129	1.0050	2610	121,700	15,410	28,400
	0.1173	1.0023	2490	111,700	14,150	26,100
			AVG 2560	AVG 116,240	AVG 14,720	AVG 27,210
-507 BORON TO BORON AND WHISKERS	0.1228	0.9955	2450	105,000	13,300	26,980
	0.1210	1.0013	2445	106,300	13,470	24,900
	0.1225	1.0015	2655	114,000	14,450	26,700
	0.1228	1.0025	2708	116,000	14,700	27,100
	0.1226	1.0024	2595	111,400	14,110	26,050
			AVG 2571	AVG 110,540	AVG 14,010	AVG 26,350
-509 BORON TO BORON AND WHISKERS	0.1279	0.9947	2075	85,500	10,820	20,150
	0.1279	1.0131	2028	87,700	10,570	19,250
	0.1288	1.0221	2215	90,500	11,470	20,700
	0.1288	0.9955	1945	79,500	10,070	18,750
	0.1272	1.0075	1980	81,900	10,380	19,000
			AVG 2049	AVG 85,020	AVG 10,660	AVG 19,570







LAYUP OF SPECIMENS

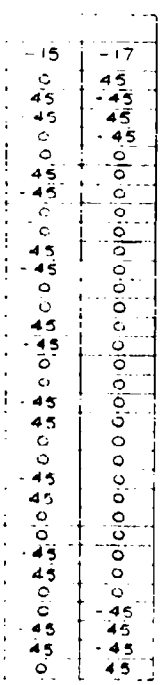
LAYER	LAYUP ANGLE ϕ°							
	-3	-5	-7	-9	-11	-13	-15	-17
1	0	45	0	45	0	45	0	45
2	45	-45	45	-45	45	-45	-45	-45
3	-45	0	-45	0	-45	45	-45	45
4	0	0	0	0	0	-45	0	-45
5	0	0	0	0	0	0	0	0
6	45	0	45	0	45	0	45	0
7	-45	0	-45	0	-45	0	-45	0
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0
10	-45	0	-45	0	45	0	45	0
11	45	-45	45	0	-45	0	-45	0
12	0	45	0	0	0	0	0	0
13			0	0	0	0	0	0
14			-45	0	-45	0	45	0
15			45	-45	45	0	-45	0
16			0	45	0	0	0	0
17					0	0	0	0
18					-45	0	45	0
19					45	0	45	0
20					0	0	0	0
21					0	-45	0	0
22					-45	45	-45	0
23					45	-45	45	0
24					0	45	0	0
25							0	0
26							-45	0
27							45	0
28							0	0
29							0	-45
30							-45	45
31							45	-45
32							0	45

A

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

GEN NOTES: UNLESS OTHERWISE NOTED

1. IDENTIFY PER DPS 3.02
2. SPECIMEN FABRICATION & PROCESSING METHODS TO BE PER DPS 1463-Z3824832
3. FIRST ISSUE RELEASE REQUIREMENTS. S EA REQ -1 THRU -513



-513	-511	-509	-507	-505	-503	-501	-1	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	STOCK SIZE	MATERIAL DESCRIPTION	MATERIAL SPECIFICATION	FIND NO.	QUAN
1	1	1	1	1	1	1	1	NAS 1252 -10H	WASHER						
1	1	1	1	1	1	1	1	NAS 679A3	NUT						
1	1	1	1	1	1	1	1	WB 22 3-6	BOLT						
4	4	4	4	4	4	4	4	-25	GRIP		.032 x 1 x 2¼	AL SHEET CLAD 2014-O	QQ-A-250/3 TEMP-O		
1	1			1	1			-23	SPACER		.160 x 1 x 2¼	AL SHEET CLAD 7075 T-6	QQ-A-250/13 TEMP T-6		
		1	1			1	1	-21	SPACER		.125 x 1 x 2¼				
2	2	2	2	2	2	2	2	-19	STRIP		.100 x 1 x 5				
1								-17	SPECIMEN		.160 x 1 x 3½	BORON (SEE TABLE)	DMS 1919		
	1							-15			.160 x 1 x 3½				
		1						-13			.120 x 1 x 3½				
			1					-11			.120 x 1 x 3½				
				1				-9			.160 x 1 x 3½	HTS GLASS (SEE TABLE)	S-994		
					1			-7			.160 x 1 x 3½				
						1		-5			.120 x 1 x 3½				
							1	-3			.120 x 1 x 3½				

LIST OF MATERIALS

MAIN NUMBERS OF THIS DRAWING (OR DASH NUMBERS SHOWN) EVEN DASH NUMBERS OPPOSITE

QUANTITY REQUIRED PER NOTED ASSY

SO 16211301

FINISH

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES.
TOLERANCES
FRACTIONS ± 1/32
DECIMALS ± .010
ANGLES ± 1/2°

MATL		
WT CHK		
STR CHK		
CHECK	E. STRAKHAN	11/30/67
PR ENGR	G. LAMPMAN	11/30/67
DES ENGR	J. CHU	11/30/67
GR ENGR		11/30/67
PREP BY	HAWLEY	11-7-67

FIRST RELEASE OF PRINTS: DEC 14 1967
ORIGINAL DATE OF DRAWING: NOV 8 1967

DESIGN ACTIVITY APPROVAL

CUSTOMER APPROVAL

SEE ENGINEERING RECORDS FOR USAGE DATA

DOUGLAS AIRCRAFT COMPANY, INC. LONG BEACH, CALIFORNIA

SPECIMEN ASSY — DOUBLE LAP BOLTED JOINT, e = 0.50

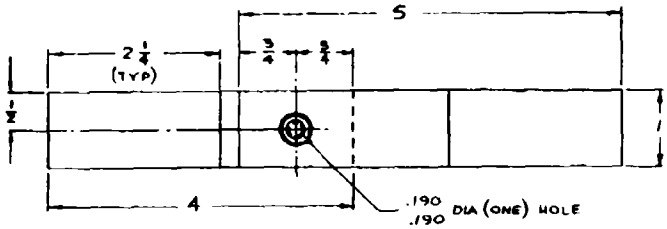
CODE IDENT NO. 88277 | SIZE D | Z3824832

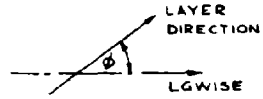
SCALE 1/1 | SHEET 1 OF 1

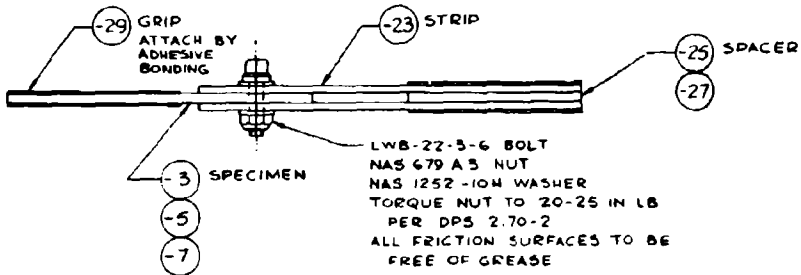
DRAWING Z3824832. SPECIMEN ASSEMBLY — DOUBLE LAP BOLTED JOINT, e = 0.50

GEN

1. ID
2. SI
   T
5. F







LAYUP OF SPECIMENS

LAYER	LAYUP ANGLE Φ°									
	-3	-5	-7	-9	-11	-13	-15	-17	-19 *	-21 *
1	0	45	0	45	0	45	0	45	0	45
2	45	-45	45	-45	45	-45	45	-45	45	-45
3	-45	0	-45	0	-45	45	-45	45	-45	45
4	0	0	0	0	0	-45	0	-45	0	-45
5	0	0	0	0	0	0	0	0	0	0
6	45	0	45	0	45	0	45	0	45	0
7	-45	0	-45	0	-45	0	-45	0	-45	0
8	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
10	-45	0	-45	0	45	0	45	0	45	0
11	45	-45	45	0	-45	0	-45	0	-45	0
12	0	45	0	0	0	0	0	0	0	0
13			0	0	0	0	0	0	0	0
14			-45	0	-45	0	45	0	-45	0
15			45	-45	45	0	-45	0	45	0
16			0	45	0	0	0	0	0	0
17					0	0	0	0	0	0
18					-45	0	-45	0	-45	0
19					45	0	45	0	45	0
20					0	0	0	0	0	0
21					0	-45	0	0	0	-45
22					-45	45	-45	0	-45	45
23					45	-45	45	0	45	-45
24					0	45	0	0	0	45
25							0	0		
26							-45	0		
27							45	0		
28							0	0		
29							0	-45		
30							-45	45		
31							45	-45		
32							0	45		

* -19 & -21 SPECIMENS ARE TO BE LAMINATED WITH WHISKERS, DETAILS OF WHICH ARE TO BE DETERMINED

SO. 16

H

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

GEN NOTES: UNLESS OTHERWISE NOTED

1. IDENTIFY PER DPS 3.02
2. SPECIMEN FABRICATION & PROCESSING METHODS TO BE PER DPS 1465-Z3824833
3. FIRST ISSUE RELEASE REQUIREMENTS: S GA CEQ -1 THRU -517

LAYER DIRECTION

LGWISE

-15	-17	-19 *	-21 *
0	45	0	45
45	-45	45	-45
-45	45	-45	45
0	-45	0	-45
0	0	0	0
45	0	45	0
-45	0	-45	0
0	0	0	0
0	0	0	0
45	0	45	0
45	0	-45	0
0	0	0	0
0	0	0	0
45	0	-45	0
45	0	45	0
0	0	0	0
0	0	0	0
45	0	-45	0
45	0	45	0
0	0	0	0
0	0	0	-45
45	0	-45	45
45	0	45	-45
0	0	0	45
0	0		
45	0		
45	0		
0	0		
0	-45		
45	45		
45	-45		
0	45		

TH WHISKERS, DETAILS

-517	-515	-513	-511	-509	-507	-505	-503	-501	-1	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	STOCK SIZE	MATERIAL DESCRIPTION	MATERIAL SPECIFICATION
1	1	1	1	1	1	1	1	1	1	NAS 1252 -10 H	WASHER				
1	1	1	1	1	1	1	1	1	1	NAS 679 A 3	NUT				
1	1	1	1	1	1	1	1	1	1	LWB-22-3-6	BOLT				
4	4	4	4	4	4	4	4	4	4	-29	GRIP		.032 x 1 x 2 1/2	AL SHEET CLAD 2014-O	QQ-A-250/3 TEMP -O
		1	1			1	1			-27	SPACER		.160 x 1 x 2 1/2	AL SHEET CLAD 7075 T-6	QQ-A-250/13 TEMP T-6
1	1			1	1			1	1	-25	SPACER		.125 x 1 x 2 1/2		
2	2	2	2	2	2	2	2	2	2	-23	STRIP		.100 x 1 x 5		
1										-21	SPECIMEN		.120 x 1 x 4	BORON [SEE TABLE]	DMS 1919
	1									-19			.120 x 1 x 4		
		1								-17			.160 x 1 x 4		
			1							-15			.160 x 1 x 4		
				1						-13			.120 x 1 x 4		
					1					-11			.120 x 1 x 4		
						1				-9			.160 x 1 x 4	HTS GLASS [SEE TABLE]	S-994
							1			-7			.160 x 1 x 4		
								1		-5			.120 x 1 x 4		
									1	-3			.120 x 1 x 4		

QUANTITY REQUIRED PER NOTED ASSY

LIST OF MATERIALS

SALES NUMBERS OF THIS MACHINE OR SUCH NUMBERS WHERE THIS MACH NUMBER APPEARS

S.O. 162/1301

FINISH

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES. TOLERANCES: FRACTIONS ± 1/32, DECIMALS ± .010, ANGLES ± 1/2°

MATL | WT CHK | STR CHK | CHECK | STR ENGR | DES ENGR | GP ENGR | PREP BY HAWLEY 11-9-67

DOUGLAS AIRCRAFT COMPANY, INC. LONG BEACH, CALIFORNIA

SPECIMEN ASSY — DOUBLE LAP BOLTED JOINT e = 0.75

SEE ENGINEERING RECORDS FOR USAGE DATA

FIRST RELEASE DEC 14 1967

ORIGINAL DATE OF DRAWING NOV 8 1967

DESIGN ACTIVITY APPROVAL

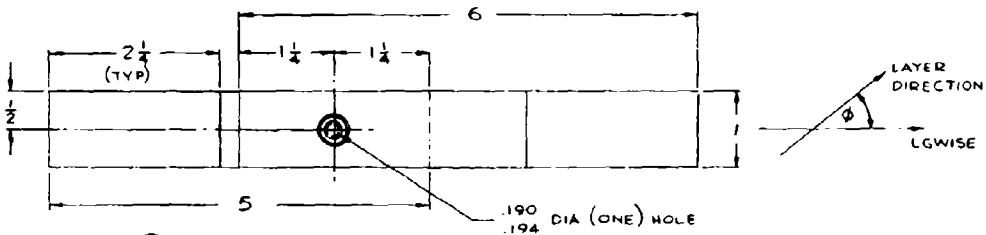
CUSTOMER APPROVAL

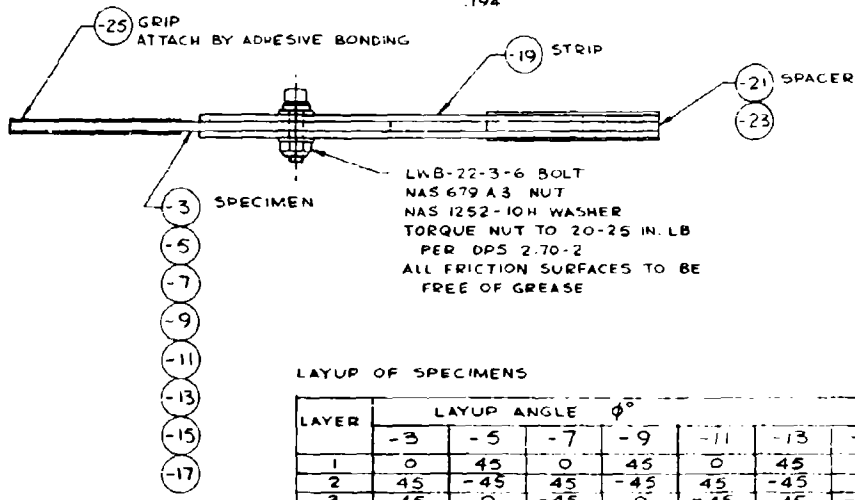
CODE IDENT NO 88277 | SIZE D | Z3824833

SCALE 1/1 | SHEET 1 OF 1

DRAWING Z3824833. SPECIMEN ASSEMBLY – DOUBLE LAP BOLTED JOINT, e = 0.75

B





LAYUP OF SPECIMENS

LAYER	LAYUP ANGLE ϕ°							
	-3	-5	-7	-9	-11	-13	-15	-17
1	0	45	0	-45	0	-45	0	45
2	45	-45	45	-45	45	-45	45	-45
3	-45	0	-45	0	-45	45	-45	45
4	0	0	0	0	0	-45	0	-45
5	0	0	0	0	0	0	0	0
6	45	0	45	0	45	0	45	0
7	-45	0	-45	0	-45	0	-45	0
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0
10	-45	0	-45	0	45	0	45	0
11	45	-45	45	0	-45	0	-45	0
12	0	45	0	0	0	0	0	0
13			0	0	0	0	0	0
14			-45	0	-45	0	45	0
15			45	-45	45	0	-45	0
16			0	45	0	0	0	0
17					0	0	0	0
18					-45	0	-45	0
19					45	0	45	0
20					0	0	0	0
21					0	-45	0	0
22					-45	45	-45	0
23					45	-45	45	0
24					0	45	0	0
25							0	0
26							-45	0
27							45	0
28							0	0
29							0	-45
30							-45	45
31							45	-45
32							0	45

A

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

GEN NOTES: UNLESS OTHERWISE NOTED

1. IDENTIFY PER DPS 3.02
2. SPECIMEN FABRICATION & PROCESSING METHODS TO BE PER DPS 1463-Z3824834
3. FIRST ISSUE RELEASE REQUIREMENTS: 5 EA REQ -1 THRU -513

LAYER DIRECTION

LGWISE

ER

-513	-511	-509	-507	-505	-503	-501	-1	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	STOCK SIZE	MATERIAL DESCRIPTION	MATERIAL SPECIFICATION	FIND NO.
1	1	1	1	1	1	1	1	NAS 1252 -10H	WASHER					
1	1	1	1	1	1	1	1	NAS 679A3	NUT					
1	1	1	1	1	1	1	1	LWB-22-3-6	BOLT					
4	4	4	4	4	4	4	4	-25	GRIP		.032 x 1 x 2 1/4	AL SHEET CLAD 2014-O	QQ-A-250/3 TEMP-O	
1	1			1	1			-23	SPACER		.160 x 1 x 2 1/4	AL SHEET CLAD 7075 T-6	QQ-A-250/13 TEMP T-6	
		1	1			1	1	-21	SPACER		.125 x 1 x 2 1/4			
2	2	2	2	2	2	2	2	-19	STRIP		.100 x 1 x 6			
1								-17	SPECIMEN		.160 x 1 x 5	BORON (SEE TABLE)	DMS1919	
	1							-15			.160 x 1 x 5			
		1						-13			.120 x 1 x 5			
			1					-11			.120 x 1 x 5			
				1				-9			.160 x 1 x 5	HTS GLASS (SEE TABLE)	S-994	
					1			-7			.160 x 1 x 5			
						1		-5			.120 x 1 x 5			
							1	-3			.120 x 1 x 5			

LIST OF MATERIALS

-15	-17
0	45
45	-45
-45	45
0	-45
0	0
45	0
-45	0
0	0
0	0
-45	0
45	0
0	0
0	0
45	0
-45	0
0	0
0	0
-45	0
45	0
0	0
0	0
-45	0
45	0
0	0
0	-45
-45	45
45	-45
0	45

QUANTITY REQUIRED PER NOTED ASSY

DASH NUMBERS OF THIS DRAWING
CEI DASH NUMBERS SHOWN
EVEN DASH NUMBERS OPPOSITE

S.O. 16211301

FINISH

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES.
TOLERANCES
FRACTIONS ± 1/32
DECIMALS ± .010
ANGLES ± 1/2°

MATL		
WT CHK		
STR CHK		
CHECK	F. SHANAHAN	11/9/67
PR ENGR	[illegible]	11/9/67
DES ENGR	[illegible]	11/9/67
GR ENGR	[illegible]	11/9/67
PREP BY	HAWLEY	11-9-67

DOUGLAS AIRCRAFT COMPANY, INC. LONG BEACH, CALIFORNIA

SPECIMEN ASSY - DOUBLE LAP BOLTED JOINT e = 1.25

SEE ENGINEERING RECORDS FOR USAGE DATA

FIRST RELEASE OF DRAWING DEC 16 1967

ORIGINAL DATE OF DRAWING NOV 8 1967

DESIGN ACTIVITY APPROVAL

CUSTOMER APPROVAL

CODE IDENT NO. 88277 | SIZE D | Z3824834

SCALE 1/1 | SHEET 1 OF 1

DRAWING Z3824834. SPECIMEN ASSEMBLY – DOUBLE LAP BOLTED JOINT, e = 1.25

B

TABLE X
DOUBLE LAP BOLTED JOINT STRENGTH SUMMARY
(0.190-INCH BOLT DIAMETER – 1-INCH SPECIMEN WIDTH)

CONFIGURATION	LAMINATE THICKNESS (IN.)	LAMINATE WIDTH (IN.)	ULTIMATE LOAD (LB)	STRESSES AT FAILURE (PSI)		
				BEARING	SHEAR-OUT	TENSION THROUGH HOLE
Z3824832	0.1019	1.0077	2190	113,000	21,490	25,900
-1	0.0999	1.0080	1890	99,600	18,920	23,150
HTS GLASS	0.0984	1.0065	1970	105,300	20,020	24,500
e = 0.50	0.0929	1.0055	1560	88,500	16,790	20,600
	0.1012	1.0052	1700	88,400	16,800	20,600
			AVG 1862	AVG 98,960	AVG 18,800	AVG 22,950
Z3824832	0.1135	0.9846	1080	50,000	9,520	11,950
-501	0.1088	0.9985	1140	51,100	10,480	12,950
HTS GLASS	0.1002	0.9835	1080	56,800	10,800	13,560
e = 0.50	0.1141	0.9796	1230	56,700	10,750	13,650
			AVG 1133	53,650	10,390	13,030
Z3824832	0.1458	0.9901	2590	93,500	17,760	22,200
-503	0.1498	1.0023	2815	98,900	18,790	23,150
HTS GLASS	0.1504	0.9937	2500	87,500	16,620	20,600
e = 0.50	0.1485	0.9902	2650	94,000	18,500	22,300
	0.1455	0.9852	2240	81,000	15,400	19,350
			AVG 2559	AVG 90,980	AVG 17,410	AVG 21,520
Z3824832	0.1389	1.0077	1420	53,800	10,210	12,500
-505	0.1352	1.0069	1260	48,600	9,330	11,400
HTS GLASS	0.1317	1.0213	1320	52,700	10,000	12,050
e = 0.50	0.1410	1.0071	1260	47,000	8,940	10,940
	0.1420	1.0080	1440	53,400	10,150	12,400
			AVG 1340	AVG 51,100	AVG 9,730	AVG 11,860
Z3824832	0.1290	1.0054	2245	91,700	17,400	21,350
-507	0.1275	1.0036	2250	93,000	17,650	21,700
BORON	0.1290	1.0044	2185	89,300	16,950	21,220
e = 0.50	0.1292	1.0018	2165	88,200	17,800	20,700
	0.1280	1.0032	2100	86,400	16,400	20,200
			AVG 2189	AVG 89,720	AVG 17,080	AVG 21,030
Z3824832	0.1321	1.0080	1505	60,000	11,390	13,910
-509	0.1320	1.0030	1475	58,800	11,180	13,750
BORON	0.1349	0.9996	1555	60,700	11,520	14,300
e = 0.50	0.1328	1.0085	1560	61,900	11,750	14,430
			AVG 1524	AVG 60,350	AVG 11,460	AVG 14,100
Z3824832	0.1700	1.0040	2740	84,800	16,150	19,800
-511	0.1702	1.0065	2760	85,400	16,210	19,850
BORON	0.1671	1.0216	2570	81,000	15,380	18,500
e = 0.50	0.1682	1.0050	2790	87,300	16,600	20,350
	0.1660	1.0035	2245	71,200	13,540	16,700
			AVG 2621	AVG 81,940	AVG 15,580	AVG 19,040
Z3824832	0.1662	1.0240	1710	54,200	10,280	12,350
-513	0.1671	1.0060	1700	53,500	10,150	12,450
BORON	0.1650	1.0060	1550	49,500	9,400	11,530
e = 0.50	0.1660	1.0062	1580	50,100	9,520	11,650
	0.1671	1.0072	1700	53,500	10,160	12,450
			AVG 1648	AVG 52,160	AVG 9,900	AVG 12,086
Z3824833	0.1022	1.0018	2290	118,000	14,920	27,300
-1	0.1048	1.0023	2390	120,000	15,210	28,100
HTS GLASS	0.0982	1.0022	2150	115,200	14,600	27,000
e = 0.75	0.1027	1.0003	2655	136,000	17,240	31,900
	0.1051	1.0023	2210	110,700	14,020	25,900
			AVG 2359	AVG 119,980	AVG 15,200	AVG 28,040

TABLE X
DOUBLE LAP BOLTED JOINT STRENGTH SUMMARY
(0.190-INCH BOLT DIAMETER – 1-INCH SPECIMEN WIDTH) (Continued)

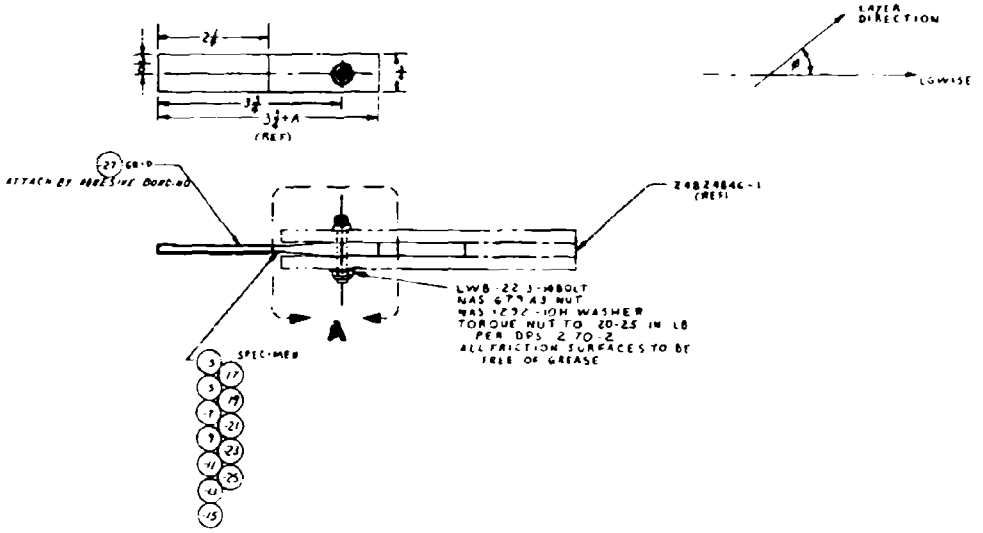
CONFIGURATION	LAMINATE THICKNESS (IN.)	LAMINATE WIDTH (IN.)	ULTIMATE LOAD (LB)	STRESSES AT FAILURE (PSI)		
				BEARING	SHEAR-OUT	TENSION THROUGH HOLE
Z3824833	0.1042	1.0021	1500	75,700	9,600	17,750
-501	0.1048	0.9994	1560	78,400	9,920	18,400
HTS GLASS	0.1030	1.0001	1650	84,300	10,680	19,800
e = 0.75	0.0983	1.0018	1970	105,300	13,350	24,700
	0.1010	1.0031	1470	76,600	9,800	17,900
			AVG 1630	AVG 84,060	AVG 10,670	AVG 19,720
Z3824833	0.1333	1.0030	3110	122,900	15,560	28,700
-503	0.1413	1.0042	2920	108,800	13,780	25,400
HTS GLASS	0.1411	1.0045	3280	122,300	15,500	28,500
e = 0.75	0.1388	1.0050	3490	132,400	16,770	26,200
	0.1380	1.0027	3420	130,500	16,530	30,500
			AVG 3244	AVG 123,380	AVG 15,630	AVG 27,860
Z3824833	0.1506	0.9971	2190	76,500	9,690	18,050
-505	0.1485	1.0182	2210	78,300	9,920	18,200
HTS GLASS	0.1498	0.9865	2190	77,000	9,750	18,300
e = 0.75	0.1545	0.9359	2510	85,500	10,830	21,750
	0.1528	0.9940	2410	83,000	10,520	19,600
			AVG 2302	AVG 80,060	AVG 10,140	AVG 19,180
Z3824832	0.1165	1.0061	3220	145,500	18,430	33,600
-507	0.1173	1.0069	2910	130,700	16,540	30,400
BORON	0.1180	1.0064	3090	137,900	17,460	32,100
e = 0.75	0.1174	1.0051	2990	134,000	16,980	31,300
	0.1175	1.0050	2930	131,300	16,630	30,600
			AVG 3028	AVG 135,880	AVG 17,210	AVG 31,600
Z3824832	0.116	1.000	2070	93,900	11,900	22,000
-509	0.115	1.000	1915	87,700	11,110	20,500
BORON	0.112	1.000	2060	96,800	12,270	22,700
e = 0.75	0.114	1.000	2300	116,200	13,460	25,300
	0.115	1.000	1950	89,300	11,310	21,400
			AVG 2059	AVG 96,780	AVG 12,010	AVG 22,380
Z3824832						
-509						
BORON	0.1112	0.9953	760	3600	4550	8500
e = 0.75	0.1109	1.0028	760	3600	4570	8430
TESTED IN	0.1115	1.0055	740	3490	4420	8130
TRANSVERSE	0.1117	1.0068	750	3530	4470	8220
DIRECTION			AVG 752	AVG 3555	AVG 4500	AVG 8320
Z3824833	0.1625	1.0006	4260	138,000	17,480	32,300
-511	0.1600	0.9945	4130	136,000	17,210	32,600
BORON	0.1578	0.9929	4270	142,500	18,040	33,700
e = 0.75	0.1608	0.9959	3980	130,300	16,500	30,700
	0.1603	1.0000	4430	145,400	18,430	34,200
			AVG 4214	AVG 138,440	AVG 17,530	AVG 32,700
Z3824833	0.1569	1.0004	2770	93,000	11,770	21,800
-513	0.1565	1.0010	2630	88,500	11,200	20,750
BORON	0.1548	0.9987	2340	79,500	10,060	18,700
e = 0.75	0.1599	0.9993	2740	90,200	11,420	21,200
	0.1600	1.0001	2540	83,500	10,590	19,600
			AVG 2604	AVG 86,940	AVG 11,010	AVG 20,410
Z3824833	0.1220	1.0193	2940	126,900	16,070	29,100
-515	0.1224	0.9982	2590	111,300	14,110	26,200
BORON AND	0.1193	0.9953	2845	125,500	15,900	29,700
WHISKERS	0.1229	0.9942	2840	121,800	15,410	28,800
	0.1224	0.9963	2336	100,300	12,720	23,700
			AVG 2710	AVG 117,160	AVG 14,840	AVG 27,500

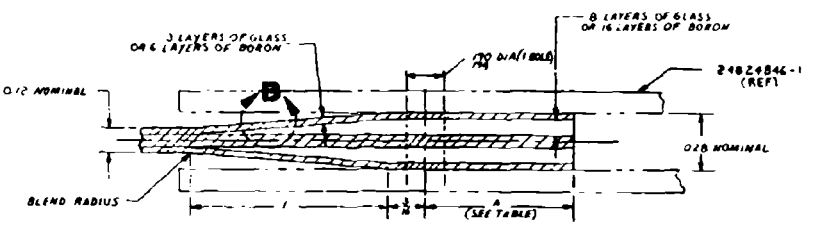
TABLE X
DOUBLE LAP BOLTED JOINT STRENGTH SUMMARY
(0.190-INCH BOLT DIAMETER – 1-INCH SPECIMEN WIDTH) (Continued)

CONFIGURATION	LAMINATE THICKNESS (IN.)	LAMINATE WIDTH (IN.)	ULTIMATE LOAD (LB)	STRESSES AT FAILURE (PSI)		
				BEARING	SHEAR-OUT	TENSION THROUGH HOLE
Z3824833 -517 BORON AND WHISKERS e = 0.75	0.1200 0.1208 0.1192 0.1178 0.1198	1.0011 1.0015 1.0162 0.9792 0.9967	2090 2300 2230 2030 2250 AVG 2180	91,700 100,200 98,300 90,700 98,900 AVG 95,960	11,610 12,690 12,470 11,490 12,520 AVG 12,160	21,500 23,400 22,900 21,900 23,300 AVG 22,600
Z3824833 -519 S-994 GLASS TO ALUMINUM BOLTED AND BONDED e = 0.75	1.000 1.000 1.000 1.000 1.000	0.0030 0.0040 0.0020 0.0035 0.0035	7650 7100 8150 7300 7150 AVG 7470		NOT APPLICABLE	
Z3824833 -521 BORON TO ALUMINUM BOLTED AND BONDED e = 0.75	1.000 1.000 1.000 1.000 1.000	0.0035 0.0025 0.0025 0.0020 0.0030	11,825 10,550 13,220 12,500 12,925 AVG 12,875		NOT APPLICABLE	
Z3824834 -1 HTS GLASS e = 1.25	0.1123 0.1030 0.1043 0.1067 0.1022	1.0014 1.0020 1.0067 1.0050 1.0018	2860 2545 2520 2650 2340 AVG 2583	134,000 129,960 127,100 130,700 120,700 AVG 128,500	11,000 9890 9650 9920 9150 AVG 9920	31,400 30,500 29,600 30,500 28,200 AVG 30,040
Z3824834 -501 HTS GLASS e = 1.25	0.1001 0.1032 0.0970 0.0955 0.1011	1.0033 1.0022 1.0000 0.9998 1.0042	2160 2030 2250 2190 2500 AVG 2226	113,300 103,500 122,000 120,800 130,100 AVG 117,940	8640 7860 9275 9175 9900 AVG 8970	26,600 24,150 28,640 28,300 30,400 AVG 27,620
Z3824834 -503 HTS GLASS e = 1.25	0.1412 0.1440 0.1510 0.1385 0.1470	1.0034 0.9998 1.0020 1.0005 1.0058	3720 3670 3820 3320 3880 AVG 3782	138,700 134,000 133,100 126,200 139,000 AVG 134,200	10,520 10,200 10,120 9,590 10,550 AVG 10,200	32,400 31,500 31,200 29,600 32,300 AVG 31,400
Z3824834 -505 HTS GLASS e = 1.25	0.1490 0.1370 0.1421 0.1402 0.1458	0.9995 0.9903 0.9994 0.9985 1.0013	2460 2760 2600 2500 2680 AVG 2600	87,000 116,700 96,300 93,900 96,700 AVG 98,120	6600 8060 7310 7140 7350 AVG 7290	20,400 25,200 22,750 22,050 22,700 AVG 22,640
Z3824834 -507 BORON	0.1205 0.1188 0.1202 0.1203 0.1201	1.0008 0.9954 0.9997 0.9985 1.0010	3460 3340 3590 3240 3470 AVG 3420	151,100 148,000 157,100 141,800 152,100 AVG 150,020	11,460 11,250 11,950 10,770 11,550 AVG 11,400	35,400 34,800 36,900 33,300 35,700 AVG 35,220
Z3824834 -509 BORON e = 1.25	0.1168 0.1158 0.1154 0.1161 0.1168	0.9998 1.0010 1.0010 0.9981 0.9995	3350 3130 3105 2590 3360 AVG 3107	151,000 142,300 141,500 117,300 151,500 AVG 140,720	11,470 10,810 10,760 8,920 11,510 AVG 10,690	35,400 33,400 33,100 27,600 35,500 AVG 33,000

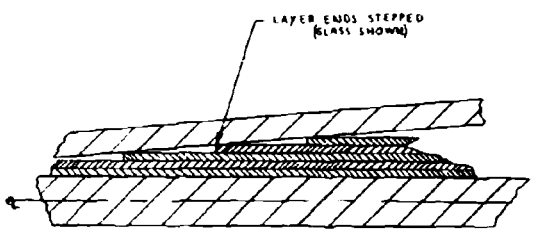
TABLE X
DOUBLE LAP BOLTED JOINT STRENGTH SUMMARY
(0.190-INCH BOLT DIAMETER – 1-INCH SPECIMEN WIDTH) (Concluded)

CONFIGURATION	LAMINATE THICKNESS (IN.)	LAMINATE WIDTH (IN.)	ULTIMATE LOAD (LB)	STRESSES AT FAILURE (PSI)		
				BEARING	SHEAR-OUT	TENSION THROUGH HOLE
Z3824834	0.1629	0.9980	4530	146,300	11,130	34,500
-511	0.1641	1.0005	4760	152,700	11,600	35,800
BORON	0.1640	0.9985	4790	153,900	11,690	36,100
e = 1.25	0.1625	0.9897	4860	157,300	11,930	37,400
	0.1638	0.9969	4840	155,600	11,820	36,600
			AVG 4756	AVG 153,160	AVG 11,630	AVG 36,080
Z3824834	0.1678	0.9905	4190	131,200	9,980	31,200
-513	0.1642	0.9927	4730	151,400	11,510	35,900
BORON	0.1640	1.0168	4410	141,400	10,750	32,500
e = 1.25	0.1675	0.9933	3940	123,800	9,420	29,300
			AVG 4317	AVG 136,695	AVG 10,420	AVG 32,230





A SCALE 4/1



INSERTED LAYERS TO FOLLOW 0/90/-45/0 SEQUENCE FROM OUTER SURFACES TOWARDS ℄

B SCALE 16/1

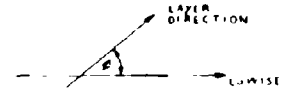
LAYUP OF SPECIMENS

	LAYUP ANGLE θ°											
A →	0.50	0.35	1.25	0.50	0.35	1.25	0.50	0.70	1.25	0.50	0.75	1.25
LAYER	-3	-5	7	-9	+11	-13	15	17	-19	-21	-23	25
1		0			45			0			45	
2		45			-45			45			-45	
3		-45			45			-45			0	
4		0			-45			0			0	
5		0			0			0			0	
6		45			0			45			0	
7		-45			0			-45			0	
8		0			0			0			0	
9		0			0			0			0	
10		45			0			-45			0	
11		-45			0			45			-45	
12		0			0			0			45	
13		0			0							
14		-45			0							
15		45			0							
16		0			0							
17		0			0							
18		-45			0							
19		45			0							
20		0			0							
21		0			-45							
22		-45			45							
23		45			-45							
24		0			45							

A

GEN NOTES UNLESS OTHERWISE NOTED

1. IDENTIFY PER DPS 502
2. SPECIMEN FABRICATION & PROCESSING METHODS TO BE PER DPS 963 Z5824838
3. FIRST ISSUE RELEASE REQUIREMENTS SEA REQ -1 THRU -521
4. ALTERNATE MATERIAL MAY BE SUBSTITUTED FOR -27 GRIP



240Z4846-1 (REF)

LAYUP OF SPECIMENS

	LAYUP ANGLE θ°											
A →	0.50	0 75	125	0.50	0 75	125	0.50	0 M	+28	0 50	0 75	+25
LAYER	-3	-5	-7	-9	-11	-13	-15	-17	-19	-21	-23	-25
1	0			90			0			90		
2	90			90			90			90		
3	90			90			90			0		
4	0			0			0			0		
5	0			0			0			0		
6	90			0			90			0		
7	90			0			90			0		
8	0			0			0			0		
9	0			0			0			0		
10	90			0			90			0		
11	90			0			90			90		
12	0			0			0			90		
13	0			0								
14	90			0								
15	90			0								
16	0			0								
17	0			0								
18	90			0								
19	90			0								
20	0			0								
21	0			90								
22	90			90								
23	90			90								
24	0			90								

	MS 1252 -10M	WASHER				
	NAS 679A3	NUT				
	LWB-22 3-14	BOLT				
-27	GRIP		0.521 IN 3	AL SHEET QUAD 2219-0	QQ-A-250/5 TEMP-O	
-25	SPECIMEN		NOTED	MTS GLASS	S-990	
-23						
-21						
-19						
-17						
-15						
-13				BORON	DMS 1919	
-11						
-9						
-7						
-5						
-3						

LIST OF MATERIALS

S.A. AL 211301
CMAO TEST PLATE

DOUGLAS — LONG BEACH, CALIFORNIA

SPECIMEN ASSY - BOLTED JOINT - REINFORCED D=.190

SIZE J | 25824838

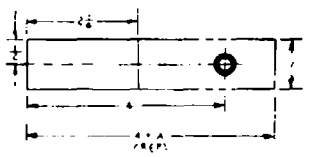
SCALE 1/1

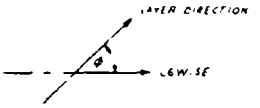
DRAWING Z5824838. SPECIMEN ASSEMBLY – BOLTED JOINT REINFORCED, D = 0.190

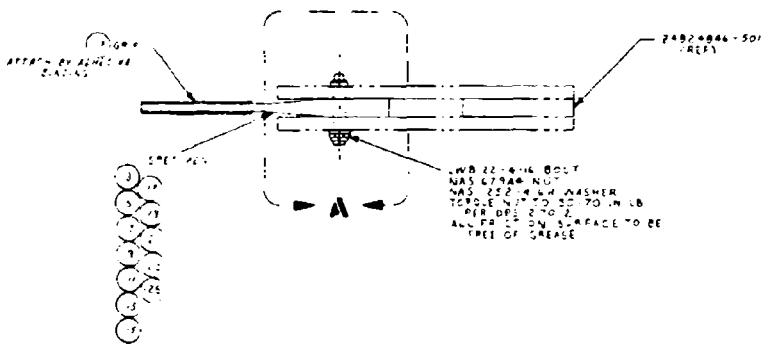
B

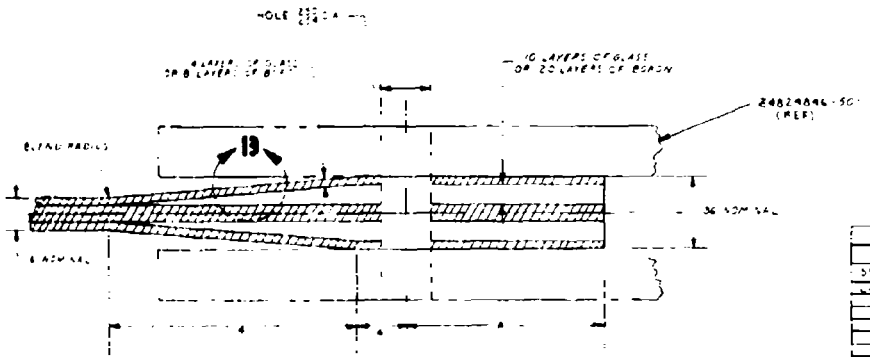
TABLE XI
REINFORCED DOUBLE LAP BOLTED JOINT STRENGTH SUMMARY
(0.190-INCH-DIAMETER BOLT)

CONFIGURATION Z5824838	LAMINATE WIDTH (IN.)	LAMINATE THICKNESS (IN.)	ULTIMATE LOAD (LB)	STRESSES AT FAILURE (PSI)		
				BEARING	SHEAR-OUT	TENSION THROUGH HOLE
1	0.774	0.278	4740	89,700	17,050	29,200
	0.766	0.280	4800	90,200	17,150	29,800
BORON	0.779	0.277	4290	81,500	15,500	26,300
	0.764	0.277	4400	84,800	15,890	27,680
e = 0.50	0.755	0.279	4780	90,100	17,120	30,340
			AVG 4602	AVG 87,300	AVG 16,500	AVG 28,660
501	0.751	0.278	7125	134,900	17,100	45,700
	0.748	0.279	7300	137,700	17,430	46,900
BORON	0.752	0.279	6700	126,300	16,000	42,700
	0.750	0.278	6325	119,700	15,150	40,500
e = 0.75	0.750	0.278	7100	134,300	17,020	45,500
			AVG 6910	AVG 130,000	AVG 16,600	AVG 44,260
503	0.754	0.278	7250	137,200	10,420	46,200
	0.753	0.278	7125	135,000	10,250	45,500
BORON	0.755	0.278	7250	137,200	10,430	46,000
	0.756	0.279	7000	132,000	10,030	44,300
e = 1.25	0.755	0.278	7450	141,000	10,710	47,400
			AVG 7215	AVG 137,000	AVG 10,400	AVG 45,880
505	0.754	0.293	3875	69,600	13,220	23,450
	0.754	0.292	3750	67,600	12,830	22,800
BORON	0.754	0.291	3900	70,500	13,400	23,760
	0.756	0.291	4100	74,100	14,090	24,860
e = 0.50	0.760	0.292	3800	68,500	13,010	22,820
			AVG 3885	AVG 70,000	AVG 13,300	AVG 23,538
507	0.755	0.301	7000	122,400	15,500	41,200
	0.753	0.302	6650	115,900	14,700	39,140
BORON	0.756	0.301	6950	121,500	15,400	40,800
	0.757	0.300	6750	118,400	15,000	39,660
e = 0.75	0.767	0.301	6575	115,000	14,570	37,860
			AVG 6785	AVG 118,500	AVG 15,000	AVG 39,732
509	0.754	0.286	7150	131,500	10,000	44,300
	0.754	0.288	7275	133,000	10,100	44,800
BORON	0.758	0.290	7000	127,000	9,650	42,500
	0.757	0.290	7025	127,300	9,690	42,700
e = 1.25	0.756	0.292	7250	130,700	9,940	43,900
			AVG 7140	AVG 130,000	AVG 9,900	AVG 43,640
511	0.748	0.283	6125	113,900	21,640	38,800
	0.769	0.293	5875	105,500	20,050	35,750
GLASS	0.751	0.275	6050	115,800	22,000	39,200
	0.753	0.280	5750	108,000	20,540	36,500
e = 0.50	0.755	0.288	6075	111,000	21,060	37,300
			AVG 5975	AVG 111,000	AVG 21,100	AVG 37,510
513	0.748	0.274	6650	127,700	16,180	43,500
	0.751	0.271	6400	124,200	15,750	42,100
GLASS	0.757	0.263	6375	127,600	16,160	42,700
	0.754	0.267	6250	123,100	15,600	41,500
e = 0.75	0.753	0.265	6275	124,600	15,780	42,100
			AVG 6390	AVG 125,500	AVG 15,800	AVG 42,380
515	0.761	0.277	6600	125,400	9,530	41,750
	0.757	0.276	6850	130,600	9,930	43,750
GLASS	0.760	0.275	6850	131,000	9,970	43,700
	0.758	0.274	6830	130,600	9,930	43,700
e = 1.25	0.760	0.275	6525	124,800	9,500	41,600
			AVG 6725	AVG 129,000	AVG 9,800	AVG 42,900
517	0.740	0.259	4375	88,900	16,000	30,440
	0.751	0.256	4930	101,200	19,250	34,300
GLASS	0.754	0.256	4770	96,800	18,400	32,640
	0.736	0.256	4920	101,100	19,200	35,200
e = 0.50	0.749	0.256	4880	100,200	19,050	34,160
			AVG 4763	AVG 97,500	AVG 18,500	AVG 33,330
519	0.755	0.275	6350	121,500	15,400	40,800
	0.760	0.273	6590	125,300	15,870	41,700
GLASS	0.749	0.273	6580	125,300	15,870	42,500
	0.754	0.275	6350	121,500	15,450	40,900
e = 0.75	0.751	0.274	6650	127,700	16,175	43,300
			AVG 6470	AVG 124,000	AVG 15,750	AVG 41,840
521	0.756	0.255	6650	137,300	10,430	46,000
	0.755	0.251	6425	134,700	10,230	45,300
GLASS	0.744	0.258	6175	126,000	9,580	43,200
	0.757	0.261	6550	132,100	10,030	44,200
e = 1.25	0.757	0.253	6390	131,000	9,970	43,900
			AVG 6429	AVG 131,000	AVG 10,009	AVG 44,520

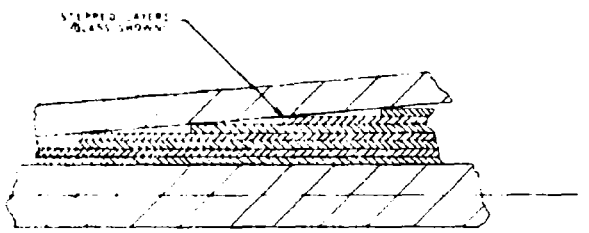








A SCALE



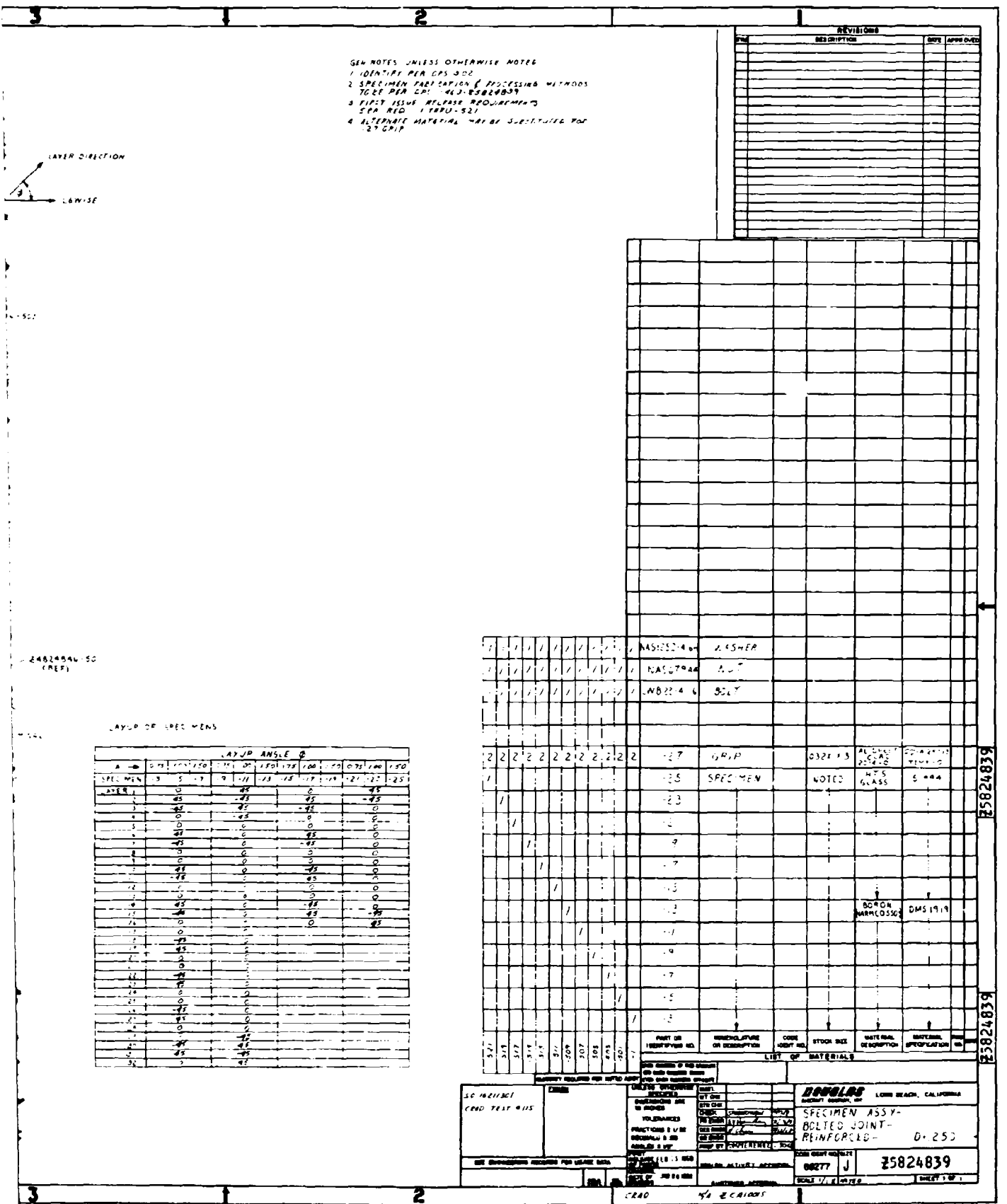
B SCALE

LAY-UP OF SPECIMENS

	LAY-UP ANGLE θ												
A →	0	±15	±30	-75	-90	+90	+75	+60	-60	-75	+90		
SPECIMEN	3	5	7	9	11	13	15	17	19	21	23		
LAYER 1	0	45			0						-45		
2	45	-45			-45			45			-45		
3	-45	45			45			-45			0		
4	0	-45			0			0			0		
5	0	0			0			0			0		
6	45	0			45			0			0		
7	-45	0			-45			0			0		
8	0	0			0			0			0		
9	0	0			0			0			0		
10	45	0			-45			0			0		
11	-45	0			45			0			0		
12	0	0			0			0			0		
13	0	0			0			0			0		
14	45	0			-45			0			0		
15	-45	0			45			0			-45		
16	0	0			0			0			45		
17	0	0											
18	-45	0											
19	45	0											
20	0	0											
21	0	0											
22	-45	0											
23	45	0											
24	0	0											
25	0	0											
26	-45	0											
27	45	0											
28	0	0											
29	0	0											
30	-45	0											
31	45	-45											
32	0	45											

DRAWIN

A

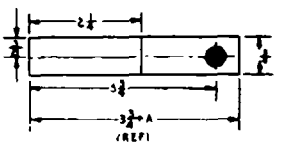


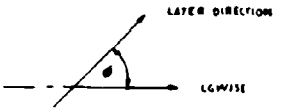
DRAWING Z5824839. SPECIMEN ASSEMBLY -- BOLTED JOINT REINFORCED, D = 0.250

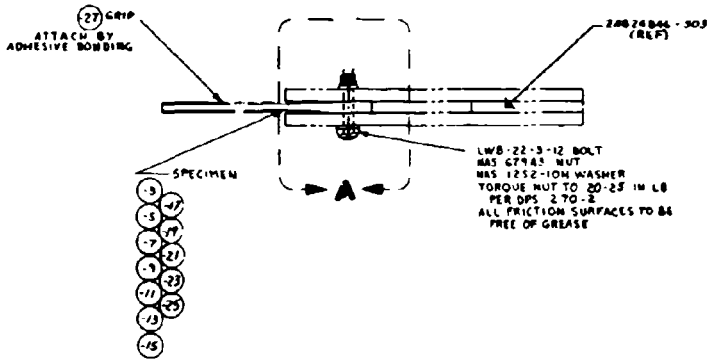
TABLE XII
REINFORCED DOUBLE LAP BOLTED JOINT STRENGTH SUMMARY
(0.250-INCH-DIAMETER BOLT)

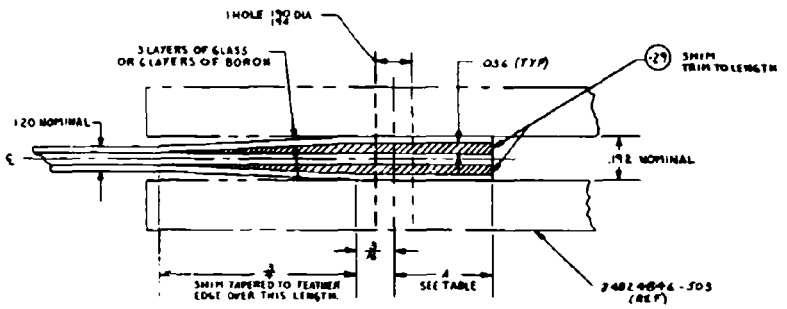
CONFIGURATION Z5824839	LAMINATE WIDTH (IN.)	LAMINATE THICKNESS (IN.)	ULTIMATE LOAD (LB)	STRESSES AT FAILURE (PSI)		
				BEARING	SHEAR-OUT	TENSION THROUGH HOLE
-1	1.0160	0.363	9015	99,300	16,540	32,400
	1.0000	0.366	8775	95,900	16,000	32,000
BORON	1.0000	0.370	9635	104,200	17,350	34,720
	1.0000	0.364	9110	100,100	16,700	33,400
e = 0.75	1.0033	0.368	9360	101,700	16,950	33,750
			AVG 9179	AVG 100,000	AVG 16,700	AVG 33,500
-501	1.0050	0.381	12,350	129,600	16,200	42,900
	1.0080	0.378	12,120	128,300	16,030	42,300
BORON	1.0070	0.382	11,725	122,800	15,360	40,600
	1.0078	0.376	11,210	119,300	14,900	39,260
e = 1.00	1.0090	0.377	12,165	129,000	16,120	42,500
			AVG 11,914	AVG 126,000	AVG 15,800	AVG 42,000
-503	1.0042	0.356	11,825	132,900	11,080	44,100
	1.0076	0.369	12,025	130,300	10,870	43,000
BORON	1.0087	0.358	11,830	132,200	11,030	43,600
	1.0087	0.361	12,100	134,000	11,180	44,200
e = 1.50	1.0070	0.364	12,325	135,400	11,300	44,700
			AVG 12,021	AVG 133,000	AVG 11,100	AVG 44,400
-505	1.0000	0.346	6810	78,700	13,120	26,240
	1.0000	0.345	6385	74,000	12,340	24,680
BORON	1.0000	0.346	6425	74,300	12,380	24,760
	1.0000	0.347	6250	72,000	12,000	24,000
e = 0.75	1.0056	0.346	5550	64,200	10,700	21,220
			AVG 6284	AVG 72,500	AVG 12,100	AVG 24,200
-507	1.0069	0.371	10,900	117,500	14,690	38,760
	1.0000	0.376	11,075	117,800	14,730	39,240
BORON	1.0000	0.367	10,550	114,900	14,370	38,300
	1.0066	0.374	11,385	121,800	15,210	40,200
e = 1.00	1.0000	0.376	9,665	102,800	12,830	34,280
			AVG 10,715	AVG 115,000	AVG 14,400	AVG 38,300
-509	1.0000	0.342	9,825	114,900	9,570	38,300
	1.0000	0.344	10,200	118,600	9,880	39,460
BORON	1.0000	0.343	10,675	124,400	10,380	41,500
	1.0000	0.343	10,175	118,600	9,900	39,560
e = 1.50	1.0000	0.343	10,625	123,800	10,330	41,400
			AVG 10,300	AVG 120,000	AVG 10,000	AVG 40,400
-511	1.0040	0.382	11,075	116,000	19,330	38,400
	1.0015	0.379	10,625	112,000	18,700	37,340
HTS GLASS	0.9994	0.385	10,675	110,900	18,500	37,000
	0.9977	0.385	11,325	117,600	19,630	39,400
e = 0.75	1.0040	0.375	10,280	109,600	18,300	36,360
			AVG 10,796	AVG 113,000	AVG 18,900	AVG 37,700
-513	1.0033	0.354	10,950	123,700	15,470	41,000
HTS GLASS	1.0060	0.352	11,440	130,000	16,270	43,000
e = 1.00	1.0069	0.348	9,520*	109,400*	13,680*	36,500*
			AVG 11,200	AVG 127,700	AVG 15,900	AVG 42,500
-515	1.0052	0.363	7,780*	85,700*	7,140*	28,600*
	1.0065	0.385	13,000	135,000	11,270	45,000
HTS GLASS	1.0017	0.389	12,200	125,000	10,450	41,800
	1.0062	0.351	10,650	121,000	10,100	40,500
e = 1.50	1.0067	0.372	11,850	127,500	10,600	42,500
			AVG 11,925	AVG 132,130	AVG 10,610	AVG 42,450
-517	1.0074	0.292	7800	106,800	17,800	35,250
	1.0033	0.310	7840	101,200	16,870	33,600
HTS GLASS	1.0048	0.324	7225	89,200	14,880	29,580
	1.0058	0.340	7225	85,000	14,170	28,040
e = 0.75	1.0034	0.355	7225	81,400	13,570	27,020
			AVG 7463	AVG 92,000	AVG 15,300	AVG 30,700
-519	1.0007	0.356	9250	103,900	13,000	34,600
	1.0023	0.327	8450	103,300	12,920	34,200
HTS GLASS	1.0053	0.368	9200	100,000	12,500	33,100
	1.0006	0.342	8435	98,700	12,320	32,850
e = 1.00	0.9960	0.313	8375	107,000	13,380	35,860
			AVG 8742	AVG 102,000	AVG 12,800	AVG 34,100
-521	1.0058	0.353	10,560	118,900	9,920	39,350
	1.0054	0.348	10,275	118,100	9,840	39,050
HTS GLASS	1.0028	0.343	10,125	118,000	9,840	39,200
	1.0028	0.360	10,925	121,400	10,110	40,400
e = 1.50	1.0036	0.356	10,325	116,000	9,670	38,500
			AVG 10,430	AVG 118,000	AVG 9,800	AVG 39,500

*OMITTED FROM AVERAGE









A No Scale

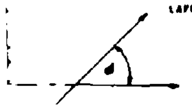
LAYUP OF SPECIMENS

	LAYUP ANGLE θ											
A	3/8	1/2	1	3/8	1/2	1	3/8	1/2	1	3/8	1/2	1
SPECIMEN	-3	-5	-7	-9	-11	-13	-15	-17	-19	-21	-23	-25
LAYER 1	0			45			0				45	
2	45			-45			45				-45	
3	45			-45			-45				0	
4	0			-45			0				0	
5	0			0			0				0	
6	45			0			45				0	
7	-45			0			-45				0	
8	0			0			0				0	
9	0			0			0				0	
10	45			0			-45				0	
11	-45			0			45				-45	
12	0			0			0				45	
13	0			0								
14	45			0								
15	-45			0								
16	0			0								
17	0			0								
18	45			0								
19	-45			0								
20	0			0								
21	0			-45								
22	45			45								
23	-45			-45								
24	0			45								

DRAW

GEN NOTES UNLESS OTHERWISE NOTED

1 IDENTIFY PER DPS 3.02
2 SPECIMEN FABRICATION / PROCESSING METHODS TO BE PER DPS 1463 - Z5824840
3 FIRST ISSUE RELEASE REQUIREMENTS. 5 EA REQ FOR -1 THRU -521
4 ALTERNATE MATERIAL MAY BE SUBSTITUTED FOR -27 GRIP
5 FINISH -29 SHIM TO DPS 9.07
6 PROCESS -29 SHIM TO DPS 4.806
7 HEAT TREAT 17-7PH COND A TO HR 210 PER DPS 5.00



-503

SHIM TRIM TO LENGTH

INAL

-503

LAYUP OF SPECIMENS

	LAYUP ANGLE θ											
A	[illegible]	1/2	1	[illegible]	1/2	1	[illegible]	1/2	1	[illegible]	1/2	1
SPECIMEN	-3	-5	-7	-9	-11	-13	-15	-17	-19	-21	-23	-25
LAYER 1	0			45			0			45		
2	45			-45			45			-45		
3	-45			45			-45			0		
4	0			-45			0			0		
5	0			0			0			0		
6	45			0			45			0		
7	-45			0			-45			0		
8	0			0			0			0		
9	0			0			0			0		
10	45			0			-45			0		
11	-45			0			45			-45		
12	0			0			0			45		
13	0			0								
14	45			0								
15	-45			0								
16	0			0								
17	0			0								
18	45			0								
19	-45			0								
20	0			0								
21	0			-45								
22	45			45								
23	-45			-45								
24	0			45								

LIST OF MATERIALS

-521	-519	-517	-515	-513	-511	-509	-507	-505	-503	-501	-1	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	STOCK SIZE	MATERIAL DESCRIPTION	MATERIAL SPECIFICATION
1	1	1	1	1	1	1	1	1	1	1	1	LWB-22-3-12	BOLT			
1	1	1	1	1	1	1	1	1	1	1	1	NAS1252-10H	WASHER			
1	1	1	1	1	1	1	1	1	1	1	1	NAS679A3	NUT			
2	2	2	2	2	2	2	2	2	2	2	2	-29	SHIM	.036 X 1 X 2	CRES SHEET TYPE 17-7PH	MIL-S-25043 COND A FINISH 2D
2	2	2	2	2	2	2	2	2	2	2	2	-27	GRIP	.092 X 1 X 3	AL SHEET CLAD 2014-O	QQ-A-250/3 TEMP-O
1												-25	SPECIMEN	5.9 MIL HTS	GLASS USING	-33 SHIM
	1											-23				
		1										-21				
			1									-19				
				1								-17				
					1							-15				
						1						-13	BORON	EPOXY 5505	TO DMS 1919	USING -33
							1					-11				
								1				-9				
									1			-7				
										1		-5				
											1	-3				

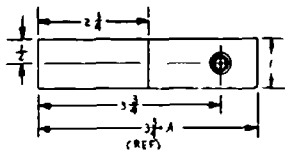
S.O. A62113H
CMD TEST HS

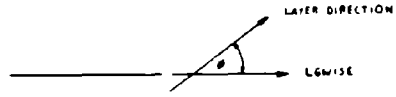
DOUGLAS AIRCRAFT COMPANY, INC. LONG BEACH, CALIFORNIA

SPECIMEN ASSY - BOLTED JOINT - SHIMMED D = .190

88277 J Z5824840

DRAWING Z5824840. SPECIMEN ASSEMBLY – BOLTED JOINT SHIMMED, D = 0.19





LAYUP OF SPECIMENS

	LAYUP ANGLE θ															
A	.030	.075	.125	.050	.075	.125	.050	.075	.125	.0						
SPECIMEN	-3	-5	-7	-9	-11	-13	-15	-17	-19	-2						
LAYER 1	0				45			0								
2	45				-45			45								
3	-45				45			-45								
4	0				-45			0								
5	0				0			0								
6	45				0			45								
7	-45				0			-45								
8	0				0			0								
9	0				0			0								
10	45				0			-45								
11	-45				0			45								
12	0				0			0								
13	0				0			0								
14	45				0			-45								
15	-45				0			45								
16	0				0			0								
17	0				0											
18	-45				0											
19	45				0											
20	0				0											
21	0				0											
22	-45				0											
23	45				0											
24	0				0											
25	0				0											
26	-45				0											
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28	0				0											
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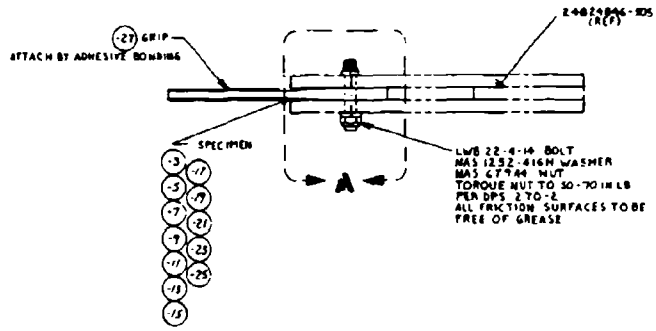
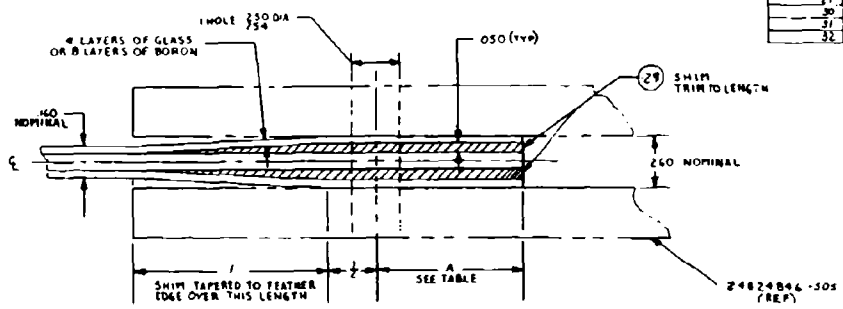
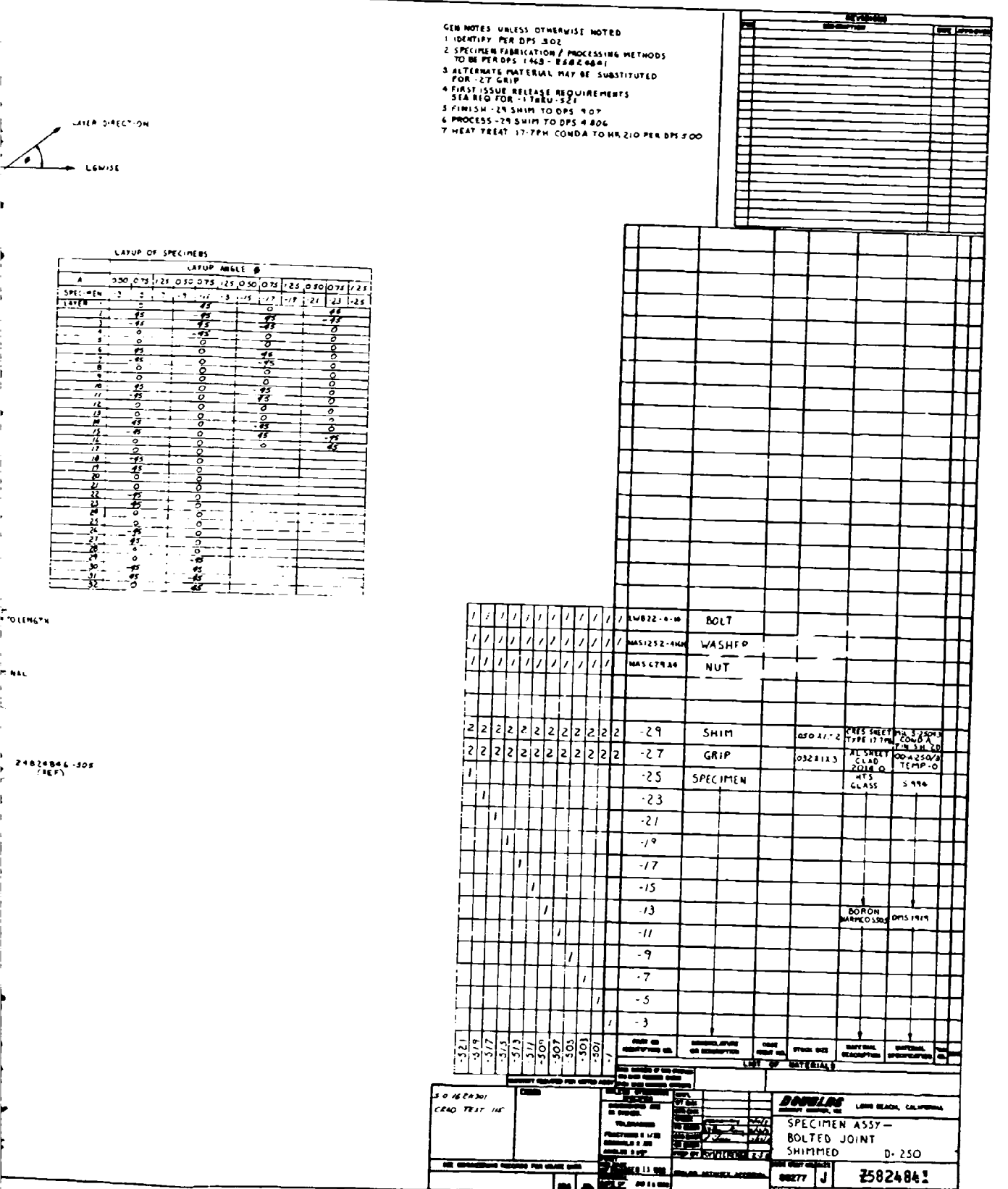




A NO SCALE

H



DRAWING Z5824841. SPECIMEN ASSEMBLY – BOLTED JOINT SHIMMED, D = 0.250

B

TABLE XIII
STEEL SHIM-REINFORCED BOLTED JOINT STRENGTH SUMMARY
(0.190-INCH-DIAMETER BOLT)

CONFIGURATION† 25824840	ULTIMATE LOAD (LB)	STRESSES AT FAILURE (PSI) BEARING	SHEAR-OUT	TENSION THROUGH HOLE	FAILURE MODES*
1 BORON e = 0.375	6,960 5,760 7,450 7,120 7,400	180,700 158,000 204,100 195,100 202,800	48,300 39,970 51,700 49,410 51,360	64,730 53,570 69,290 66,220 68,820	B, C, D
	AVG 6,938	AVG 190,140	AVG 48,050	AVG 64,530	
501 BORON e = 0.50	6,560 5,940 6,580 7,600	179,740 162,760 180,290 208,240	34,110 30,890 34,220 39,520	61,010 55,240 61,190 70,680	B, C, D
	AVG 6,670	AVG 182,760	AVG 34,690	AVG 62,030	
503 BORON e = 1.000	7,400 8,025 8,930 6,210 8,560	202,760 219,890 244,680 170,150 232,900	19,240 20,870 23,220 16,150 22,100	68,820 74,630 83,050 57,750 79,050	B B A, E B E
	AVG 7,813	AVG 214,080	AVG 20,320	AVG 72,660	
505 BORON e = 0.375	7,100 6,700 6,800 6,840	194,540 183,580 180,320 187,420	49,270 46,500 47,190 47,470	66,030 62,310 63,240 63,610	C, D
	AVG 6,893	AVG 187,970	AVG 47,610	AVG 63,780	
507 BORON e = 0.50	8,420 7,420 7,560 6,800 8,260	230,710 203,310 206,870 186,320 226,320	43,780 38,580 39,260 35,360 42,960	78,310 69,010 70,220 63,240 76,820	C, D
	AVG 7,690	AVG 210,710	AVG 39,990	AVG 71,520	
509 BORON e = 1.000	5,525 7,625 8,300 9,180	151,390** 208,930 227,420 251,530	14,370** 19,830 21,580 23,870	51,380 70,910 77,190 85,370	A** C A A, C
	AVG 8,360	AVG 229,290	AVG 21,760	AVG 77,820	
511 GLASS e = 0.375	4,400 4,660 4,420 4,720	120,560 127,680 121,110 129,330	30,540 32,340 30,680 32,760	40,920 43,340 41,110 43,900	B, C
	AVG 4,550	AVG 124,670	AVG 31,580	AVG 42,320	
513 GLASS e = 0.50	5,340 5,000 5,280 4,960 5,940	146,320 137,000 144,120 135,900 162,760	27,770 26,000 27,350 25,790 30,890	49,660 46,500 48,920 46,130 55,240	B, C
	AVG 5,300	AVG 145,220	AVG 27,560	AVG 49,290	
515 GLASS e = 1.00	5,200 4,920 5,030 4,950 4,930	142,480 134,810 137,820 135,630 135,080	13,520 12,790 13,080 12,870 12,820	48,360 46,760 46,530 46,040 45,850	B, C
	AVG 5,006	AVG 137,160	AVG 13,020	AVG 46,510	
517 GLASS e = 0.375	3,850 3,700 4,300 4,200 4,300	105,490 101,380 117,820 115,080 117,820	26,720 25,680 29,840 29,150 29,840	35,810 34,410 39,990 39,060 39,990	B, C, D
	AVG 4,070	AVG 111,520	AVG 28,250	AVG 37,850	
519 GLASS e = 0.50	5,100 4,940 5,630 5,500 5,600	139,740 135,360 154,260 150,700 153,440	26,520 25,690 29,270 28,600 29,120	47,430 45,940 52,360 51,150 52,080	B
	AVG 5,354	AVG 146,700	AVG 27,840	AVG 49,790	
521 GLASS e = 1.0	5,200 5,200 5,380 5,300 5,500	142,480 142,480 147,410 145,220 150,700	13,520 13,520 13,990 13,780 14,300	48,360 48,360 50,030 47,700 51,150	B, C
	AVG 5,316	AVG 145,660	AVG 13,820	AVG 49,120	

† LAMINATE WIDTH EQUALS 0.750 IN., THICKNESS EQUALS 0.192 IN.

* FAILURES LISTED FOR 5 SPECIMENS DO NOT NECESSARILY OCCUR SIMULTANEOUSLY OR IN EACH SPECIMEN.

FAILURE MODES
- A. BOLT SHEAR
- B. TENSION IN LAMINATE AT BASE OF SHIMS
- C. SHIM DELAMINATION AND LAMINATE SHEAR-OUT
- D. TENSION IN LAMINATE AND SHIM AT SECTION THROUGH FASTENER HOLE
- E. TENSION IN OUTER PLIES OF LAMINATE AT BASE OF SHIMS AND AT SECTION THROUGH FASTENER HOLE IN PLIES BETWEEN SHIMS, PARTIAL DELAMINATION OF SHIMS

** PREMATURE BOLT FAILURE AT THREAD ROOT SECTION – OMITTED FROM AVERAGE

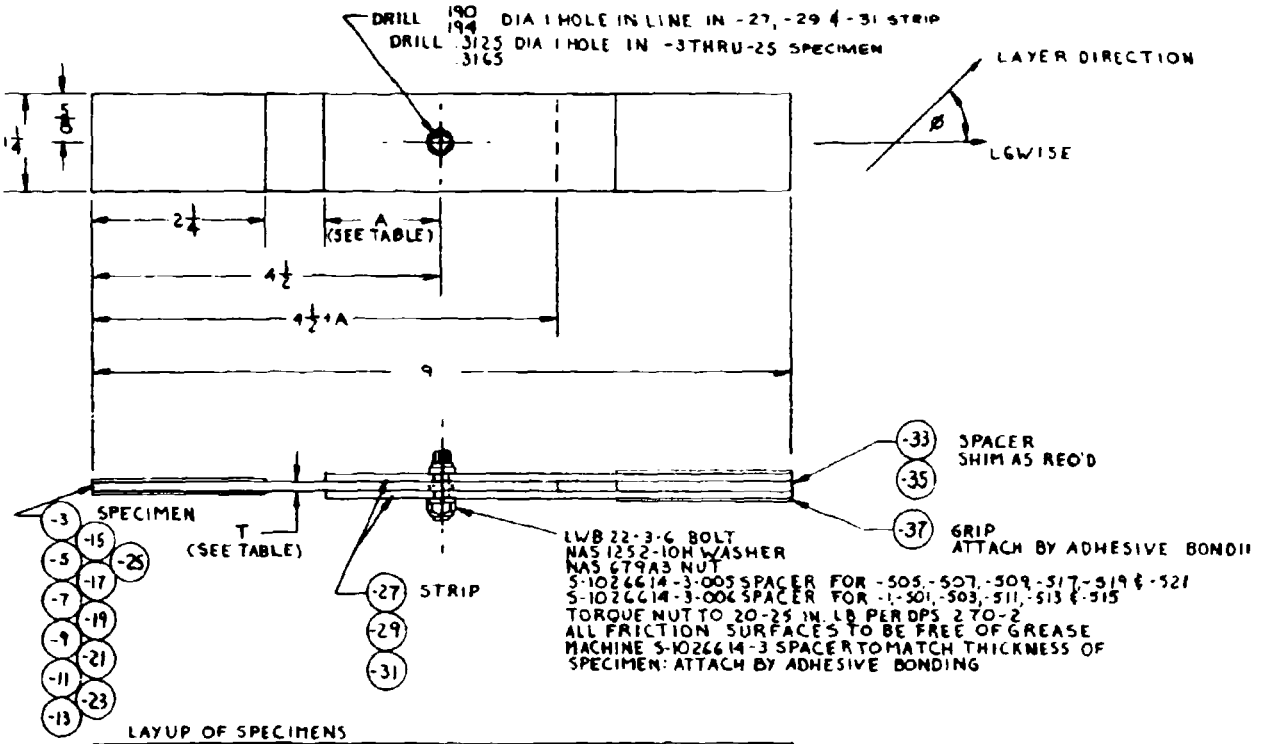
TABLE XIV
STEEL SHIM-REINFORCED BOLTED JOINT STRENGTH SUMMARY
(0.250-INCH-DIAMETER BOLT)

CONFIGURATION[1] ZS824841	ULTIMATE LOAD (LB)	STRESSES AT FAILURE (PSI) BEARING	SHEAR-OUT	TENSION THROUGH HOLE	FAILURE MODES*
-1 BORON e = 0.50	13,000 13,000 12,900 13,300 11,900	200,200 200,200 198,660 204,820 183,260	50,050 50,050 49,680 51,210 45,820	66,690 66,690 66,180 68,230 61,050	D
	AVG 12,820	AVG 197,430	AVG 49,360	AVG 65,770	
-501 BORON e = 0.75	13,000 11,800 11,700 14,700	200,200 181,720 180,180 226,380	33,280 30,210 29,950 37,630	66,690 60,530 60,020 75,410	B, D
	AVG 12,800	AVG 197,120	AVG 32,780	AVG 65,660	
-503 BORON e = 0.437	12,075 12,025 11,925 12,573 11,150	185,960 185,190 183,650 193,620 171,710	53,010 52,790 52,350 55,200 48,950	61,950 61,690 61,190 64,500 57,200	D D E E D
	AVG 11,905	AVG 184,030	AVG 52,460	AVG 61,300	
-505 BORON e = 0.50	12,150 11,800 11,800 12,150	187,110 181,720 181,720 186,340	46,780 45,430 45,430 46,780	62,330 60,530 60,530 62,330	C, D
	AVG 11,975	AVG 184,220	AVG 46,110	AVG 61,430	
-507 BORON e = 0.75	15,100 14,300 14,800 15,400 14,900	232,540 220,220 227,920 237,160 229,460	38,660 36,610 37,890 39,420 38,140	77,460 73,360 75,920 79,000 76,440	B, C, D
	AVG 14,900	AVG 229,460	AVG 38,140	AVG 76,440	
-509 BORON e = 1.25	14,900 14,800	229,460 227,920	22,950 22,790	76,440 75,920	A A, G
	AVG 14,800	AVG 228,690	AVG 22,870	AVG 76,180	
-509 BORON e = 0.437	9,975 11,600 10,825	153,620 178,640 166,710	43,820 50,920 47,520	51,170 59,510 55,530	F F F
	AVG 10,800	AVG 166,320	AVG 47,420	AVG 55,400	
-511 GLASS e = 0.50	7,850 6,780 7,870 6,400 6,960	120,890 104,412 121,198 98,560 107,184	30,220 26,100 30,300 24,640 26,800	40,270 34,800 40,370 32,830 35,710	C, D
	AVG 7,172	AVG 110,450	AVG 27,610	AVG 36,800	
-513 GLASS e = 0.75	8,840 9,000 8,600 9,000 9,000	136,136 138,600 132,440 138,600 138,600	22,630 23,040 22,020 23,040 23,040	45,350 46,170 44,120 46,170 46,170	C
	AVG 8,888	AVG 136,880	AVG 22,750	AVG 45,600	
-517 GLASS e = 0.50	7,460 6,960 7,070 6,960 7,100	114,884 107,184 108,878 107,184 109,340	28,720 26,800 27,220 26,800 27,340	38,270 35,710 36,270 35,710 36,470	C
	AVG 7,100	AVG 109,490	AVG 27,380	AVG 36,480	
-519 GLASS e = 0.75	7,500 7,580 7,180 7,240 7,460	115,500 116,732 110,572 111,496 114,884	19,200 19,410 18,400 18,530 19,100	38,480 38,890 36,830 37,140 38,270	C
	AVG 7,392	AVG 114,540	AVG 18,930	AVG 37,970	
-521 GLASS e = 1.25	8,100 7,880 8,730 8,200 7,800	124,740 121,352 134,442 126,280 120,120	12,470 12,140 13,400 12,630 12,010	41,550 40,420 44,790 42,070 40,010	C, D
	AVG 8,142	AVG 125,390	AVG 12,530	AVG 41,770	

[1] LAMINATE WIDTH EQUALS 1.0 IN.; THICKNESS EQUALS 0.260 IN.

* FAILURES LISTED FOR 5 SPECIMENS DO NOT NECESSARILY OCCUR SIMULTANEOUSLY OR IN EACH SPECIMEN.

FAILURE MODES
- A. BOLT SHEAR
- B. TENSION IN LAMINATE AT BASE OF SHIMS
- C. SHIM DELAMINATION AND LAMINATE SHEAR-OUT
- D. TENSION IN LAMINATE AND SHIM AT SECTION THROUGH FASTENER HOLE
- E. TENSION IN LAMINATE AND ONE SHIM, TENSION AND SHEAR-OUT IN SECOND SHIM
- F. SHEAR-OUT OF LAMINATE AND ONE SHIM, TENSION IN SECOND SHIM
- G. TENSION IN OUTER PLIES OF LAMINATE AT BASE OF SHIMS AND AT SECTION THROUGH FASTENER HOLE IN PLIES BETWEEN SHIMS, PARTIAL DELAMINATION OF SHIMS



LAYUP OF SPECIMENS

SPECIMEN	LAYUP ANGLE Ø											
	-3	-5	-7	-9	-11	-13	-15	-17	-19	-21	-23	-25
T	.160			.120			.160			.120		
A	1	1 1/2	2	1	1 1/2	2	1	1 1/2	2	1	1 1/2	2
LAYER 1	0			0			0			0		
2	45			45			45			45		
3	-45			-45			-45			-45		
4	0			0			0			0		
5	0			0			0			0		
6	45			45			45			45		
7	-45			-45			-45			-45		
8	0			0			0			0		
9	0			0			0			0		
10	45			45			-45			-45		
11	-45			-45			45			45		
12	0			0			0			0		
13	0			0			0					
14	45			-45			-45					
15	-45			45			45					
16	0			0			0					
17	0			0								
18	-45			-45								
19	45			45								
20	0			0								
21	0			0								
22	-45			-45								
23	45			45								
24	0			0								
25	0											
26	-45											
27	45											
28	0											
29	0											
30	-45											
31	45											
32	0											

GEN NOTES UNLESS OTHERWISE NOTED
1 IDENTIFY PER DPS 302
2 SPECIMEN FABRICATION & PROCES METHODS TO BE PER DPS 1463-23,
3 FIRST ISSUE RELEASE REQUIREM SEA REQ -1 THRU -521
4 ALTERNATE AL SHEET MAY BE US FOR -33 & -35 SPACER AND -37

A

R DIRECTION

E

O'D

ADHESIVE BONDING

7-519 & -521
& -515

SE
S OF

S OTHERWISE NOTED
PS 302
ICATION & PROCESSING
E PER DPS 1463-Z3824856
LEASE REQUIREMENTS:
RU-521
SHEET MAY BE USED
SPACER AND -37 GRIP

REVISIONS

SYM	DESCRIPTION	DATE	APPROVED

-521	-519	-517	-515	-513	-511	-509	-507	-505	-503	-501	-1	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	STOCK SIZE	MATERIAL DESCRIPTION	MATERIAL SPECIFICATION	SPEC NO.
1	1	1	1	1	1	1	1	1	1	1		LWB22-3-6	BOLT					
			1	1	1				1	1	1	S-1026614-3-005	SPACER					
1	1	1				1	1	1				S-1026614-3-006						
1	1	1	1	1	1	1	1	1	1	1	1	NAS1252-10H	WASHER					
1	1	1	1	1	1	1	1	1	1	1	1	NAS 679A3	NUT					
4	4	4	4	4	4	4	4	4	4	4	4	-37	GRIP		.032 X 1 1/4 X 2 1/4	AL SHEET CLAD 2014-O	QQ-A-250/3 TEMP-O	
			1	1	1				1	1	1	-35	SPACER		.160 X 1 1/4 X 2 1/4	AL SHEET CLAD 7075 T-6	QQ-A-250/13 TEMP T-6	
1	1	1				1	1	1				-33	SPACER		.125 X 1 1/4 X 2 1/4			
2		2		2		2			2			-31	STRIP		.100 X 1 1/4 X 6 1/2 GR 6GW12E			
	2		1		2		2			2		-29			.100 X 1 1/4 X 6 GR 6GW12E			
		2				2		2			2	-27			.100 X 1 1/4 X 5 1/2 GR 6GW12E			
1												-25	SPECIMEN		.120 X 1 1/4 X 6 1/2	HTS GLASS	S-994	
	1											-23			.120 X 1 1/4 X 6			
		1										-21			.120 X 1 1/4 X 5 1/2			
			1									-19			.160 X 1 1/4 X 6 1/2			
				1								-17			.160 X 1 1/4 X 6			
					1							-15			.160 X 1 1/4 X 5 1/2			
						1						-13			.120 X 1 1/4 X 6 1/2	BORON NARMCO5505	DMS 1919	
							1					-11			.120 X 1 1/4 X 6			
								1				-9			.120 X 1 1/4 X 5 1/2			
									1			-7			.160 X 1 1/4 X 6 1/2			
										1		-5			.160 X 1 1/4 X 6			
											1	-3			.160 X 1 1/4 X 5 1/2			

LIST OF MATERIALS

QUANTITY REQUIRED PER NOTED ASSY

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES
FRACTIONS ± 1/32
DECIMALS ± .05
ANGLES ± 1/2°

MATL		
WT CHK		
STR CHK		
CHECK	P. STRAHAN	9/7/67
PR ENGR	[illegible]	9/6/67
DES ENGR	[illegible]	9/7/67
QR ENGR	[illegible]	9-7-67
PREP BY	DONNA BETTLES	9-7-67

DOUBLAS AIRCRAFT COMPANY, INC — LONG BEACH, CALIFORNIA

SPECIMEN ASSY — BUSHED JOINT

CODE IDENT NO. 88277 | SIZE D | Z3824856

SCALE 1/1 | SHEET 1 OF

SEE ENGINEERING RECORDS FOR USAGE DATA

FIRST RELEASE OF PRINTS ORIGINAL 29 11 568

DATE OF ORIGINAL FEB 28 1968

RELEASE ACTIVITY APPROVAL

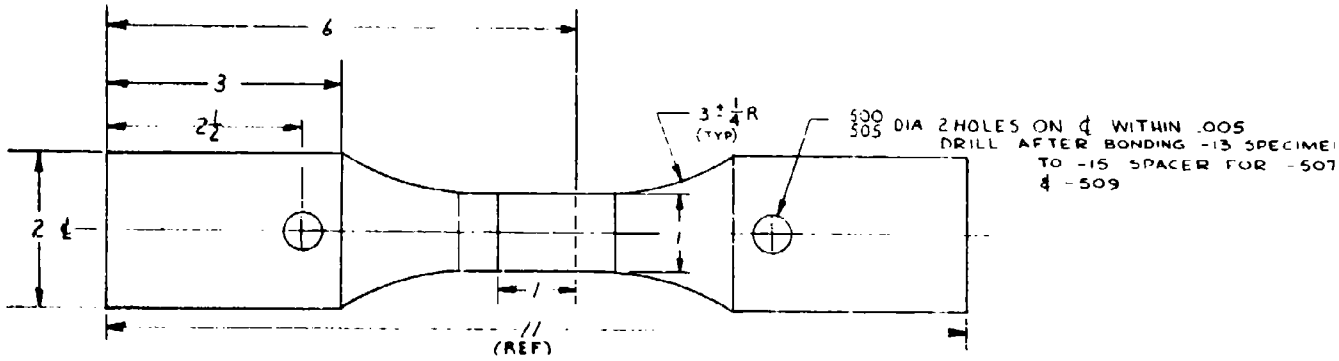
CUSTOMER APPROVAL

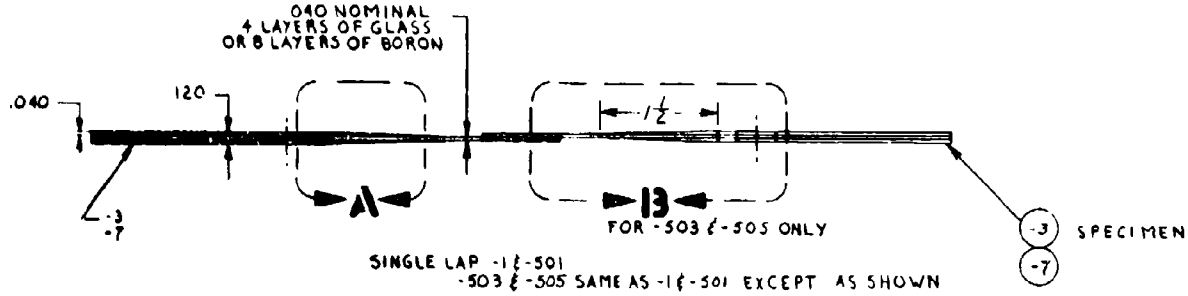
DRAWING Z3824856. SPECIMEN ASSEMBLY – BUSHED JOINT

16

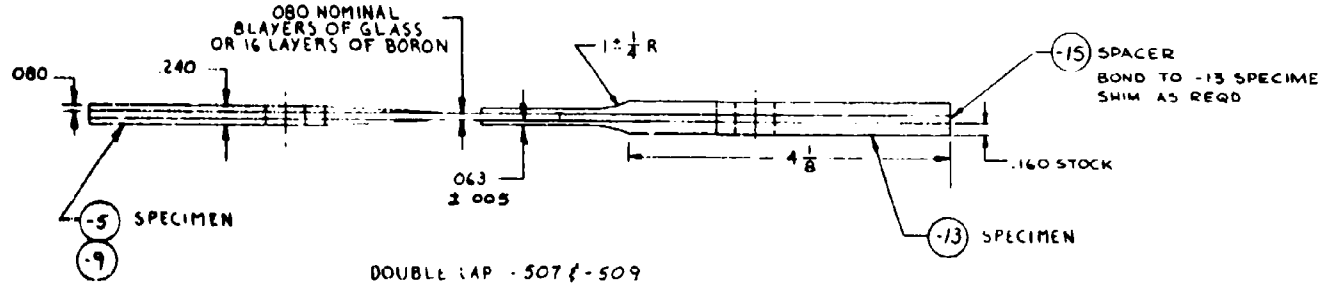
TABLE XV
DOUBLE LAP BOLTED JOINT STRENGTH SUMMARY – BUSHED HOLE

CONFIGURATION Z3824856	LAMINATE WIDTH (IN.)	LAMINATE THICKNESS (IN.)	ULTIMATE LOAD (LB)	STRESSES AT FAILURE (PSI)		
				BEARING	SHEAR-OUT	TENSION THROUGH HOLE
-1	1.261	0.169	3855	73,000	11,400	24,040
	1.260	0.172	4010	74,500	11,660	24,600
BORON	1.260	0.169	4140	78,400	12,260	25,860
	1.260	0.173	3985	73,700	11,510	24,300
e = 1.0	1.260	0.173	4020	74,400	11,620	24,540
			AVG 4002	AVG 74,800	AVG 11,690	AVG 24,670
501	1.240	0.178	4340	78,000	8,130	25,800
	1.250	0.169	4615	87,400	9,100	28,850
BORON	1.260	0.169	4625	87,600	9,120	28,860
	1.260	0.172	4475	83,200	8,670	27,460
e = 1.5	1.260	0.168	4565	87,000	9,060	28,700
			AVG 4524	AVG 84,640	AVG 8,820	AVG 27,930
503	1.260	0.178	4705	84,600	6,600	27,820
	1.280	0.187	4440	75,900	5,930	25,000
BORON	1.250	0.171	4555	85,300	6,630	28,150
	1.275	0.174	4460	82,000	6,410	27,000
e = 2.0	1.250	0.171	4665	87,300	6,820	28,820
			AVG 4565	AVG 83,020	AVG 6,480	AVG 27,360
505	1.260	0.128	3470	86,800	13,570	28,600
	1.250	0.128	3643	91,100	14,240	30,080
BORON	1.250	0.128	2895	72,400	11,310	23,900
	1.225	0.128	3608	90,200	14,100	29,860
e = 1.0	1.275	0.123	3460	90,000	14,070	29,650
			AVG 3415	AVG 86,100	AVG 13,460	AVG 28,420
507	1.250	0.126	4045	102,700	10,700	33,900
	1.260	0.123	3730	97,000	10,100	32,000
BORON	1.237	0.125	3700	94,750	9,870	31,340
	1.260	0.130	3960	97,500	10,160	32,150
e = 1.5	1.260	0.127	3890	98,000	10,210	32,370
			AVG 3865	AVG 98,000	AVG 10,220	AVG 32,340
509	1.260	0.127	4510	113,700	8,870	37,150
	1.270	0.127	4700	118,400	9,250	39,000
BORON	1.270	0.126	5425	137,900	10,760	45,400
	1.225	0.127	4210	106,000	8,280	36,340
e = 2.0	1.270	0.127	4570	115,200	9,000	38,000
			AVG 4683	AVG 118,240	AVG 9,230	AVG 39,240
511	1.250	0.174	4290	80,700	12,610	26,650
	1.250	0.173	4015	74,250	11,600	24,500
GLASS	1.250	0.159	4110	82,700	12,920	27,300
	1.250	0.164	4200	83,900	13,100	27,700
e = 1.0	1.250	0.167	4450	85,300	13,320	28,150
			AVG 4253	AVG 81,330	AVG 12,710	AVG 26,860
513	1.225	0.170	4895	92,000	9,600	31,500
	1.250	0.160	4885	97,700	10,190	31,580
GLASS	1.240	0.174	4995	92,000	9,570	30,920
	1.240	0.171	5002	93,700	9,750	31,540
e = 1.5	1.250	0.156	4670	95,900	9,990	31,940
			AVG 4889	AVG 94,260	AVG 9,820	AVG 31,400
515	1.250	0.129	5155	128,000	10,000	42,600
	1.240	0.157	5055	101,000	8,050	34,700
GLASS	1.235	0.163	5235	102,900	8,030	34,800
	1.225	0.150	5100	108,900	8,500	37,200
e = 2.0	1.225	0.133	4460	107,300	8,380	36,740
			AVG 5001	AVG 110,000	AVG 8,590	AVG 37,210
517	1.250	0.127	3345	84,400	13,180	28,100
	1.240	0.127	3405	85,800	13,400	28,600
GLASS	1.260	0.129	4020	99,800	15,590	32,900
	1.230	0.128	3410	85,300	13,320	29,020
e = 1.0	1.250	0.127	3255	82,100	12,870	27,350
			AVG 3487	AVG 87,480	AVG 13,660	AVG 29,700
519	1.225	0.119	3700	99,500	10,370	34,050
	1.240	0.124	4060	104,390	10,920	35,260
GLASS	1.250	0.115	3285	91,500	9,520	30,410
	1.240	0.124	4120	106,300	11,090	35,830
e = 1.5	1.255	0.126	3960	100,600	10,490	33,140
			AVG 3825	AVG 100,540	AVG 10,480	AVG 33,760
521	1.225	0.119	4035	108,500	8,470	37,120
	1.240	0.126	4245	113,200	9,840	38,190
GLASS	1.250	0.123	4160	108,300	8,460	36,700
	1.260	0.120	4050	108,000	8,440	35,650
e = 2.0	1.225	0.124	4330	113,900	8,830	38,750
			AVG 4174	AVG 110,200	AVG 8,810	AVG 37,150

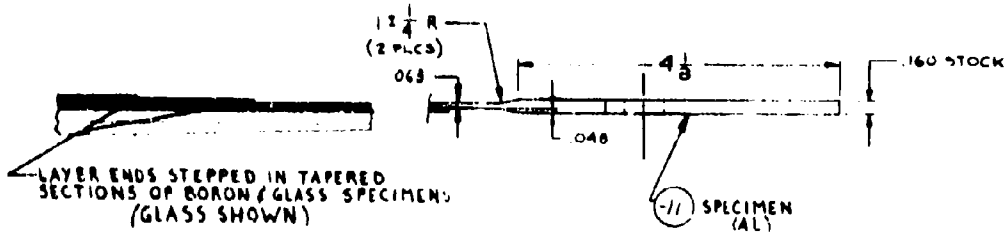




SINGLE LAP -1 & -501
-503 & -505 SAME AS -1 & -501 EXCEPT AS SHOWN



DOUBLE LAP -507 & -509



A SCALE 4

13 FOR -503 & -505
SAME AS -1 & -501
EXCEPT 11 SPECIMEN
SUBSTITUTED AT ONE END

H

WITHIN .005
BONDING -13 SPECIMENS
5 SPACER FOR -507
09

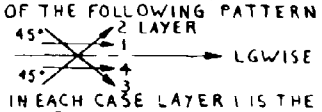
SPECIMEN

5) SPACER
BOND TO -13 SPECIMENS
SHIM AS REQD

DCK

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

GEN NOTE UNLESS OTHERWISE NOTED
1. IDENT BY PER DPS 302
2. SPECIMEN FAB & PROCESSING METHODS PER S 1463-Z3824849
3. BOND WITH SHELL 951 ADHESIVE
4. LAMINATES ARE MADE UP OF MULTIPLES OF THE FOLLOWING PATTERN:



IN EACH CASE LAYER 1 IS THE OUTERMOST LAYER AND LAY-UP IS SYMMETRICAL ABOUT THE MID-PLANE OF THE LAMINATE
5. FIRST ISSUE RELEASE REQUIREMENTS 5 EA REQ -1 THRU -505
6. ALTERNATIVE AL SHEET MAY BE USED FOR -15 SPACER

-509	-507	-505	-503	-501	-1	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	STOCK SIZE	MATERIAL DESCRIPTION	MATERIAL SPECIFICATION	FIND NO.
1	1					-15	SPACER		.080 x 2 x 3 OR LGWISE OR DPT	AL SHEET CLAD 7075-O	QQ-A-250/13 TEMP O	
2	2					-13	SPECIMEN		OR LGWISE 160X2X6	AL SHEET CLAD 7075 T-6	QQ-A-250/13 TEMP T-6	
		1	1			-11			↓	↓	↓	
1						-9			NOTED X 2X6	HTS GLASS	S-994	
		1		2		-7			↓	↓	↓	
	1					-5			NOTED X 2X6	BORON NARMCO 5505	DMS 1919	
			1		2	-3			↓	↓	↓	

LIST OF MATERIALS

QUANTITY REQUIRED PER NOTED ASSY

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES FRACTIONS ± 1/32 DECIMALS ± .010 ANGLES ± 1°

MATL
WT ON
FIN ON
CHKD
PR ENGR HAWLEY 2-25-69
PROD
QA
PROJ ENGR

DOUGLAS AIRCRAFT COMPANY, INC. LONG BEACH, CALIFORNIA

SPECIMEN ASSY - FATIGUE - LAP JOINT

SEE ENGINEERING RECORDS FOR USAGE DATA

DESIGN ACTIVITY APPROVAL

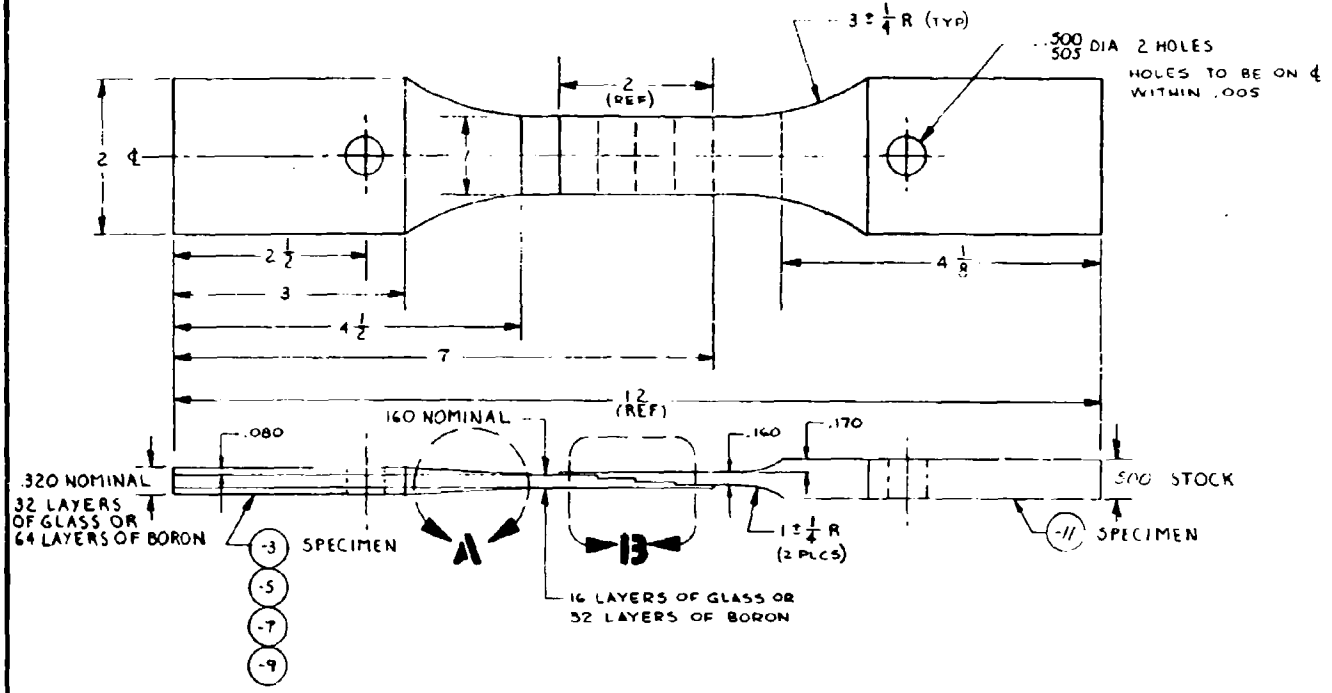
CUSTOMER APPROVAL

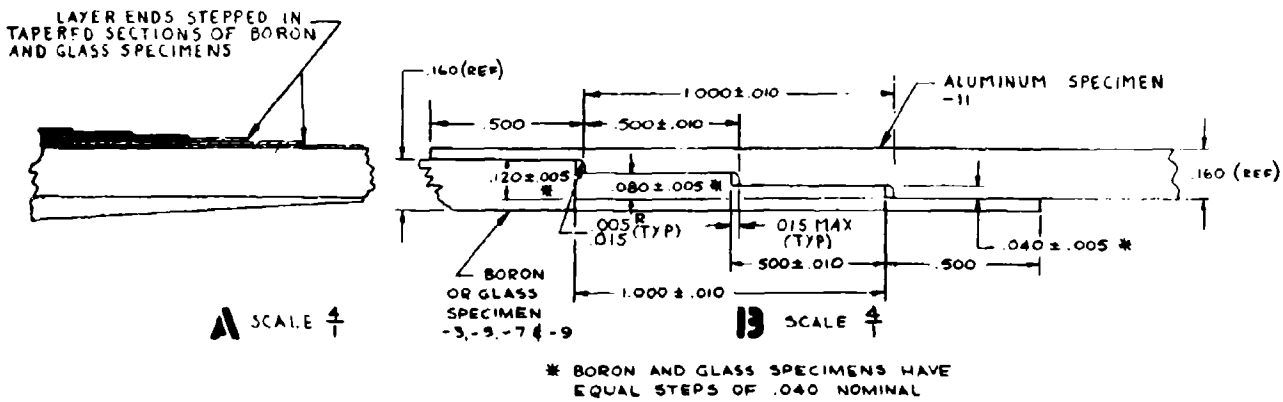
USER IDENT NO. 88277 | SIZE D | Z3824849

SCALE 1/1 | SHEET 1 OF 1

DRAWING Z3824849. SPECIMEN ASSEMBLY - FATIGUE LAP JOINT

13


3 ± 1/4 R (TYP)
.500 .505 DIA 2 HOLES
HOLES TO BE ON ℄ WITHIN .005
2 (REF)
2 ℄
2 1/2
3
4 1/2
7
4 1/8
12 (REF)
.080
160 NOMINAL
.160
.170
.320 NOMINAL
32 LAYERS OF GLASS OR 64 LAYERS OF BORON
.500 STOCK
-3
-5
-7
-9
SPECIMEN
A
B
1 ± 1/4 R (2 PLCS)
-11
SPECIMEN
16 LAYERS OF GLASS OR 32 LAYERS OF BORON


LAYER ENDS STEPPED IN TAPERED SECTIONS OF BORON AND GLASS SPECIMENS
.160 (REF)
1.000 ± .010
ALUMINUM SPECIMEN -11
.500
.500 ± .010
.120 ± .005 *
.080 ± .005 *
.160 (REF)
.005 R .015 (TYP)
.015 MAX (TYP)
.040 ± .005 *
.500 ± .010
.500
1.000 ± .010
BORON OR GLASS SPECIMEN -3, -5, -7 ℄ -9
A SCALE 4/1
B SCALE 4/1
* BORON AND GLASS SPECIMENS HAVE EQUAL STEPS OF .040 NOMINAL

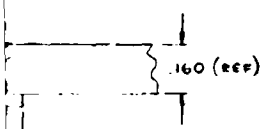
A

HOLES
LES TO BE ON ℄
THIN .005

STOCK

IMEN

M SPECIMEN



REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

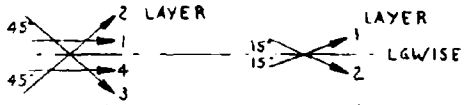
GEN NOTES: UNLESS OTHERWISE NOTED

1 IDENTIFY PER DPS 302

2 SPECIMEN FAB & PROCESSING METHODS PER DPS 1463-238 1485?

3 BOND WITH SHELL 951 ADHESIVE

4 LAMINATES ARE MADE UP OF MULTIPLES OF THE FOLLOWING PATTERNS



A (-5 ℄ -9) B (-3 ℄ -7)

IN EACH CASE LAYER 1 IS THE OUTERMOST LAYER AND LAYUP IS SYMMETRICAL ABOUT THE MID-PLANE OF THE LAMINATE

5 FIRST ISSUE RELEASE REQUIREMENTS: SEA REQ -1 THRU -505

-505	-503	-501	-1	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	STOCK SIZE	MATERIAL DESCRIPTION	MATERIAL SPECIFICATION	FIND NO.	NOTE
1	1	1	1	-11	SPECIMEN		½ X 2 X 7 GR LGWISE	AL PLATE 7075-T651	QQ-A-250/12 TEMP T651		
1				-9			NOTED X 2 X 7	PATTERN A 32 LAYERS	5-994 NTS GLASS		
	1			-7				PATTERN B 32 LAYERS			
		1		-5				PATTERN A 64 LAYERS	BORON DMS 1919		
			1	-3				PATTERN B 64 LAYERS			

LIST OF MATERIALS

QUANTITY REQUIRED PER NOTED ASSY

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES FRACTIONS ± 1/32 DECIMALS ± .010 ANGLES ± 1/2°

MATL
WT. CON.
FIN. CON.
DESIGN
STRESS
WEIGHT
CHKD BY

DOUGLAS AIRCRAFT COMPANY, INC. LONG BEACH, CALIFORNIA

SPECIMEN ASSY - FATIGUE - STEPPED LAP

SEE ENGINEERING RECORDS FOR USAGE DATA

RELEASED 29 1968

RELEASE AUTHORITY APPROVAL

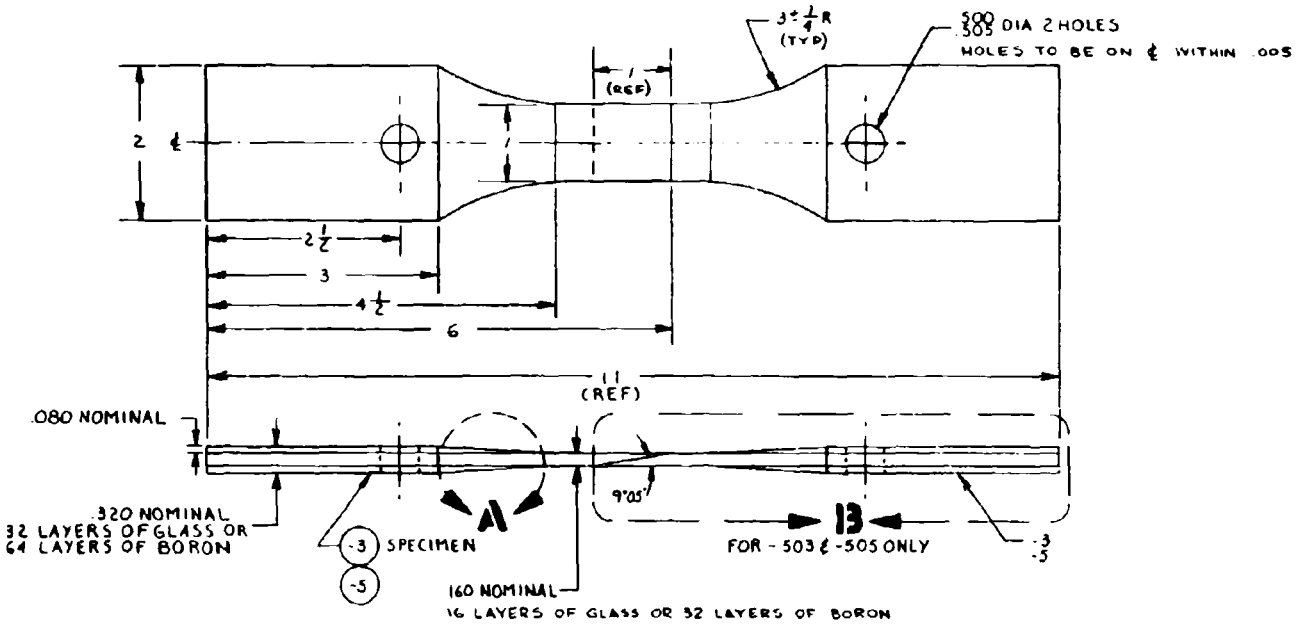
CUSTOMER APPROVAL

CODE IDENT NO. 06277 SIZE D Z3824850

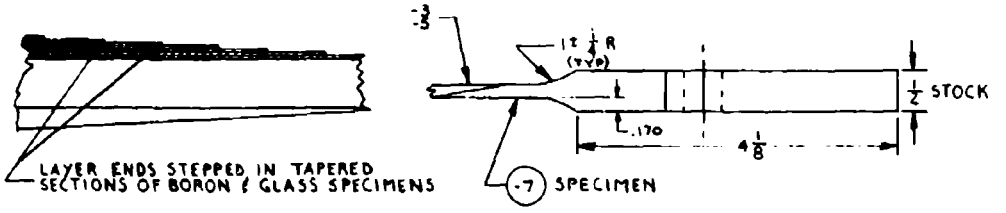
SCALE 11/1 SHEET 1 OF

DRAWING Z3824850. SPECIMEN ASSEMBLY – FATIGUE STEPPED LAP

B



-1 & -501
-503 & -505 SAME AS -1 & -501 EXCEPT AS SHOWN



A SCALE 4/1

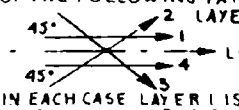
B FOR -503 & -505

A

HOLES
BE ON ℄ WITHIN .005

GEN NOTES UNLESS OTHERWISE NOTED

1. IDENTIFY PER DPS 3.02
2. SPECIMEN FAB & PROCESSING METHODS PER DPS 1463-Z3824851
3. BOND WITH SHELL 951 ADHESIVE
4. LAMINATES ARE MADE UP OF MULTIPLES OF THE FOLLOWING PATTERN:



IN EACH CASE LAYER 1 IS THE OUTERMOST LAYER AND LAY-UP IS SYMMETRICAL ABOUT THE MIDPLANE OF THE LAMINATE

5. FIRST ISSUE RELEASE REQUIREMENTS: 5 EA REQ -1 THRU -505

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

½ STOCK

-505	-503	-501	-1	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	STOCK SIZE	MATERIAL DESCRIPTION	MATERIAL SPECIFICATION	PROP NO.	NOTE
1	1			-7	SPECIMEN		½ X 2 X 6 GR LGWISE	AL PLATE 7075 T651	QQ-A-250/12 TEMP T651		
1		2		-5			NOTED X 2 X 6	HTS GLASS	S-994		
	1		2	-3				BORON NARMCO 5505	DMS 1919		

LIST OF MATERIALS

QUANTITY REQUIRED PER NOTED ASSY

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES FRACTIONS ± 1/32 DECIMALS ± .005 ANGLES ± 1/2°

DOUGLAS AIRCRAFT COMPANY, INC. LONG BEACH, CALIFORNIA

SPECIMEN ASSY — FATIGUE — SCARF

SEE ENGINEERING RECORDS FOR USAGE DATA

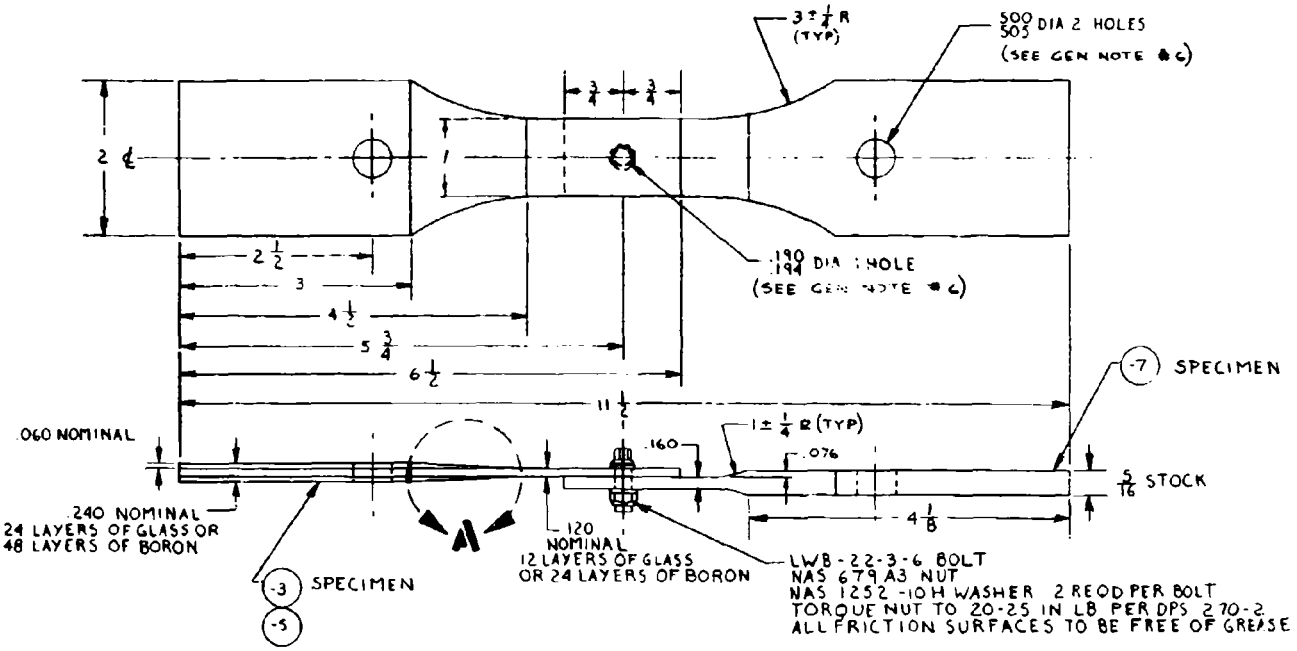
CODE IDENT NO. 88277 SIZE D

Z3824851

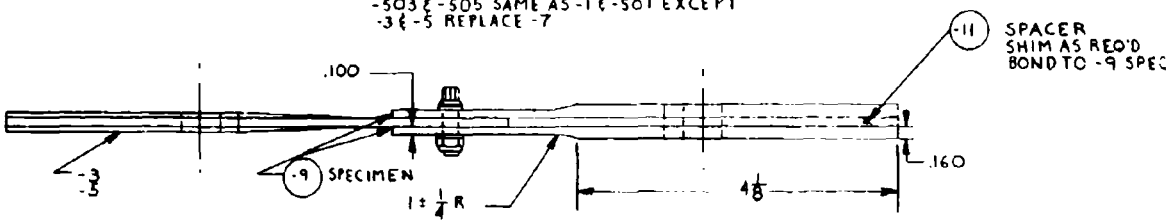
SCALE 1/1 SHEET 1 OF

DRAWING Z3824851. SPECIMEN ASSEMBLY – FATIGUE SCARF

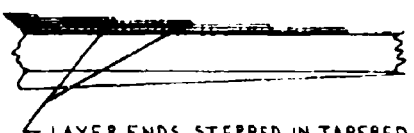
B



-1 ℄ -501
-503 ℄ -505 SAME AS -1 ℄ -501 EXCEPT
-3 ℄ -5 REPLACE -7



-507 ℄ -509
-511 ℄ -513 SAME AS -507 ℄ -509 EXCEPT
BOND SPECIMENS WITH SHELL 951 BEFORE
DRILLING HOLE



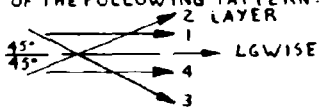
LAYER ENDS STEPPED IN TAPERED SECTIONS OF BORON & GLASS SPECIMENS
(GLASS SHOWN)

A SCALE 4/1

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED
A	SEE SHT 2	9/6/61	[illegible]

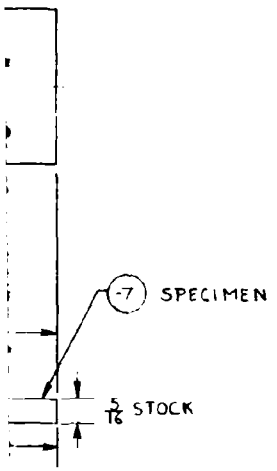
GEN NOTES: UNLESS OTHERWISE NOTED

1. IDENTIFY PER DPS 302
2. SPECIMEN FAB & PROCESSING METHODS PER DPS 1.469-Z3824852
3. LAMINATES ARE MADE UP OF MULTIPLES OF THE FOLLOWING PATTERN:

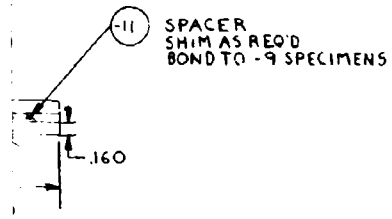


IN EACH CASE LAYER 1 IS THE OUTERMOST LAYER AND LAY-UP IS SYMMETRICAL ABOUT THE MID-PLANE OF THE LAMINATE

4. FIRST ISSUE RELEASE REQUIREMENTS: 5 EA REQ -1 THRU -509
5. ALTERNATIVE AL SHEET MAY BE USED FOR -11 SPACER
6. HOLES TO BE ON ℄ WITHIN .005



R 2 REQ'D PER BOLT
IN LB PER DPS 270-2
LES TO BE FREE OF GREASE



-513	-511	-509	-507	-505	-503	-501	-1	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	STOCK SIZE	MATERIAL DESCRIPTION	MATERIAL SPECIFICATION	PROD. SEA.
2	2	2	2	2	2	2	2	NAS 1252-10H	WASHER					
1	1	1	1	1	1	1	1	NAS 679A3	NUT					
1	1	1	1	1	1	1	1	LWB-22-3-6	BOLT					
1	1	1	1					-11	SPACER		100 X 2 X 3 GR OPT	AL SHEET CLAD 7075 T-6	QQ-A-250/13 TEMP T-6	
2	2	2	2					-9	SPECIMEN		160 X 2 X 7 GR LGWISE	AL SHEET CLAD 7075 T-6	QQ-A-250/13 TEMP T-6	
						1	1	-7			5/16 X 2 X 7 GR LGWISE	AL PLATE 7075 T651	QQ-A-250/12 TEMPT651	
1		1		2		1		-5			NOTED X 2 X 6½	HTS GLASS	S-994	
	1		1		2		1	-3				BORON NARMCO5505	DMS1919	

LIST OF MATERIALS

QUANTITY REQUIRED PER NOTED ASSY

FINISH

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES FRACTIONS ± 1/32 DECIMALS ± .015 ANGLES ± 1°

MATL.		
WT CHK		
STR CHK		
CHECK	E. Schumann	8/23/61
PR ENGR	MAWLEY	9-23-61
DES ENGR	[illegible]	9-26-61
GR ENGR	[illegible]	9/27/61
PROJ ENGR	[illegible]	9-28-61

DOUGLAS AIRCRAFT COMPANY, INC LONG BEACH, CALIFORNIA

SPECIMEN ASSY — FATIGUE — SINGLE & DOUBLE LAP — BOLTED JOINT

SEE ENGINEERING RECORDS FOR USAGE DATA

RELEASED FEB 20 1958

DATE OF LAST CHANGE FEB 21 1958

ORIGIN ACTIVITY APPROVAL

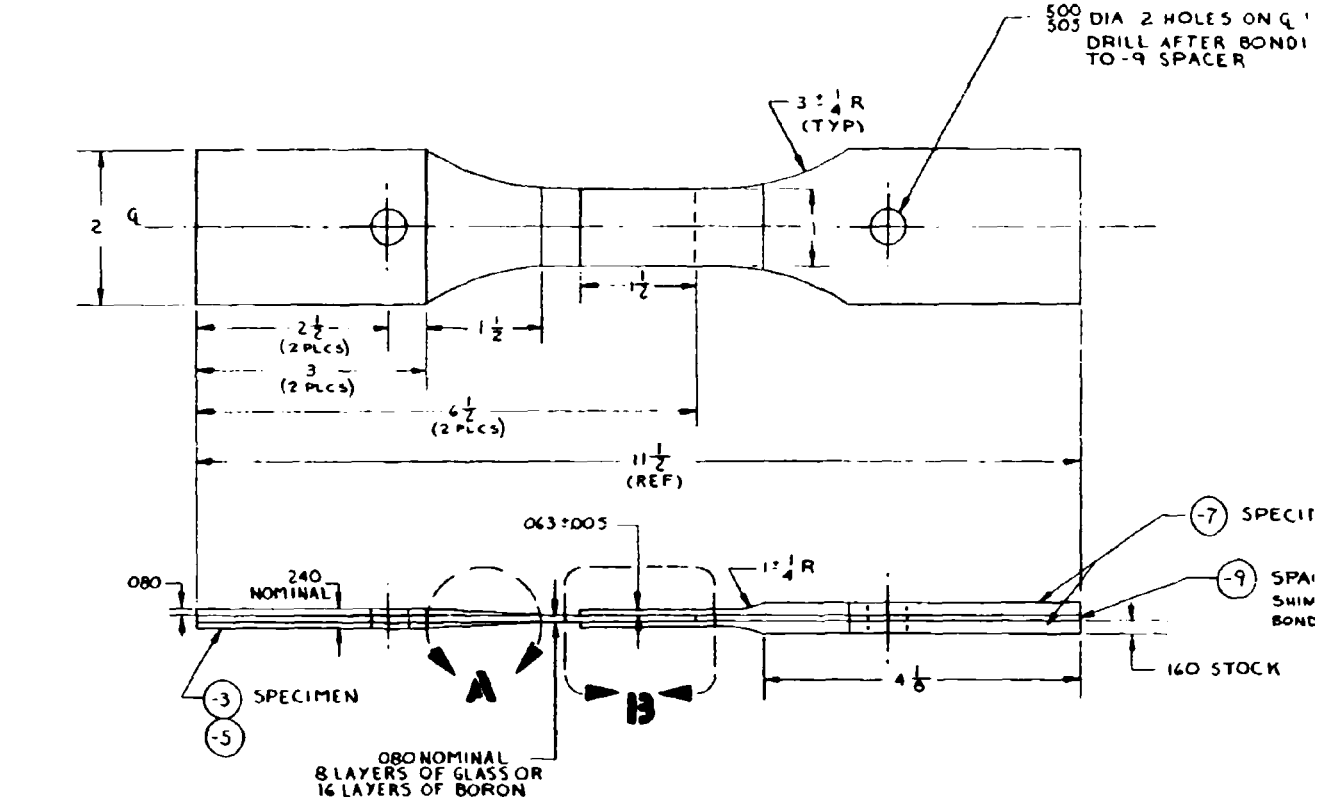
CUSTOMER APPROVAL

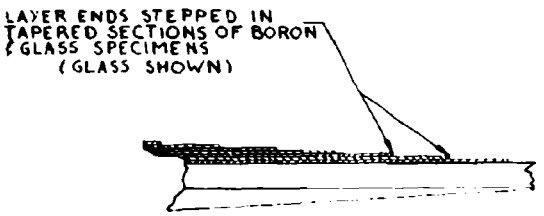
CODE IDENT NO. 88277 | SIZE D | Z3824852

SCALE 1/1 | SHEET 1 OF 1

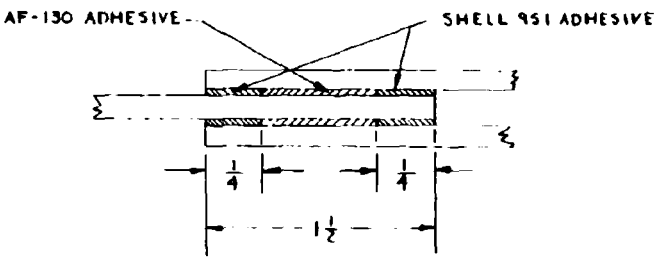
DRAWING Z3824852. SPECIMEN ASSEMBLY – FATIGUE SINGLE AND DOUBLE LAP BOLTED JOINT

B





A SCALE 4/1



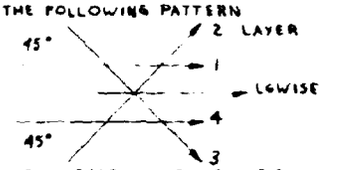
B NOT TO SCALE

H

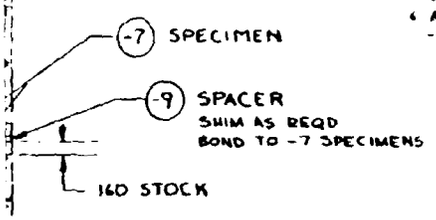
REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

3 DIA 2 HOLES ON ℄ WITHIN .005
DRILL AFTER BONDING -7 SPECIMENS
TO -9 SPACER

GEN NOTES UNLESS OTHERWISE NOTED
1 IDENTIFY PER DPS 302
2 SPECIMEN FAB & PROCESSING METHODS PER DPS 1463-Z3824855
3 BOND WITH SHELL 951 & AF-130 AS SHOWN IN VIEW 'B'
4 LAMINATES ARE MADE UP OF MULTIPLES OF THE FOLLOWING PATTERN



IN EACH CASE LAYER 1 IS THE OUTERMOST LAYER AND LAYUP IS SYMMETRICAL ABOUT THE MID PLANE OF THE LAMINATE
5 FIRST ISSUE RELEASE REQUIREMENTS SEA REQ -1 & -501
6 ALTERNATIVE AL SHEET MAY BE USED FOR -9 SPACER



ELL 951 ADHESIVE

ALE

1	1	-9	SPACER		.080 X 2 X 3	AL SHEET CLAD 7075-O	QQ-A-250/13 TEMP-O	
2	2	-7	SPECIMEN		.160 X 2 X 6 1/2 LGWISE	AL SHEET CLAD 7075 T-6	QQ-A-250/13 TEMP T-6	
1		-5	↓		NOTED X 2 X 6 1/2	MTS GLASS	S-994	
	1	-3	SPECIMEN		NOTED X 2 X 6 1/2	BORON NARMCO 5505	DMS 1919	
-501	-1	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	STOCK SIZE	MATERIAL DESCRIPTION	MATERIAL SPECIFICATION	FINISH NO.

LIST OF MATERIALS

QUANTITY REQUIRED PER NEXT HIGHER ASSY

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES
FRACTIONS ± 1/32
DECIMALS ± .005
ANGLES ± 1/2°

MATL
WT GRS
SPR GRS
CHECK
PR ENGR
QUA ENGR
QA ENGR
PROD EV

DOUGLAS AIRCRAFT COMPANY, INC. LONG BEACH, CALIFORNIA

SPECIMEN ASSY—
VARIABLE ADHESIVE JOINT—
FATIGUE

SEE ENGINEERING RECORDS FOR USABLE DATA

POST PRELIMINAR 11 1968
DATE OF RELEASE FEB 8 1968

DESIGN ACTIVITY APPROVAL
CUSTOMER APPROVAL

CODE IDENT NO. 88277 | SIZE D | Z3824855

SCALE 1/1 | SHEET 1 OF

DRAWING Z3824855. SPECIMEN ASSEMBLY – VARIABLE ADHESIVE JOINT FATIGUE

B

TABLE XVI
SUMMARY OF FATIGUE TEST RESULTS – JOINT CONCEPT SCREENING TESTS

JOINT TYPE	MATERIALS AND GAGES (IN.)	OVERLAP LENGTH (IN.)	MAXIMUM LOAD / MINIMUM LOAD (LB)	MAXIMUM LOAD % OF STATIC ULTIMATE	TESTS	ADHESIVE STRESS AT MAXIMUM LOAD (PSI)	APPROXIMATE SCF IN ADHESIVE	(SCF) X AVERAGE STRESS AT MAXIMUM LOAD (PSI)	RANGE OF CYCLES TO FAILURE	FAILURE MODE
SINGLE LAP	BORON/ALUMINUM (0.040)/(0.063)	1	1800/90	72	5	1,800	4.8	8,600	8,000 TO 35,000	ADHESIVE
	FIBER GLASS/ALUMINUM (0.040)/(0.063)	1	1600/80	69	5	-	-		10,700 TO 19,400	ADHESIVE
DOUBLE LAP	BORON/ALUMINUM (0.080)/(0.126)	1	6400/260	70	5	3,200	3.4	10,900	480 TO 1,860	ADHESIVE
	FIBER GLASS/ALUMINUM (0.080/(0.126)	1	4200/200	73	2				1,700 TO 2,300	ADHESIVE
		1	3400/170	60	3				1,600 TO 8,500	ADHESIVE
	BORON/ALUMINUM (0.160)/(0.160)	2	3600/330	66	3	3,300	3.6	11,900	1,000 TO 5,000	ADHESIVE
FOUR-STEP LAP	BORON/ALUMINUM (0.160)/(0.160) PATTERN C	2	8200/410	70	2	4,100	3.6	14,700	760 TO 2,000	ADHESIVE
		2	6600/330	67	2	3,300	3.6	11,900	7,800 TO 12,720	ADHESIVE
	FIBER GLASS/ALUMINUM (0.160)/(0.160)	2	6600/330	75	5	-		-	200 TO 300	ADHESIVE
SCARF	BORON/ALUMINUM (0.160)/(0.160)	1	3300/165	70	5	3,300	1.4	4,600	16,000 TO 119,000	ADHESIVE
	FIBER GLASS/ALUMINUM (0.160)/(0.160)	1	3800/190	70	5		-		1,400 TO 20,000	ADHESIVE

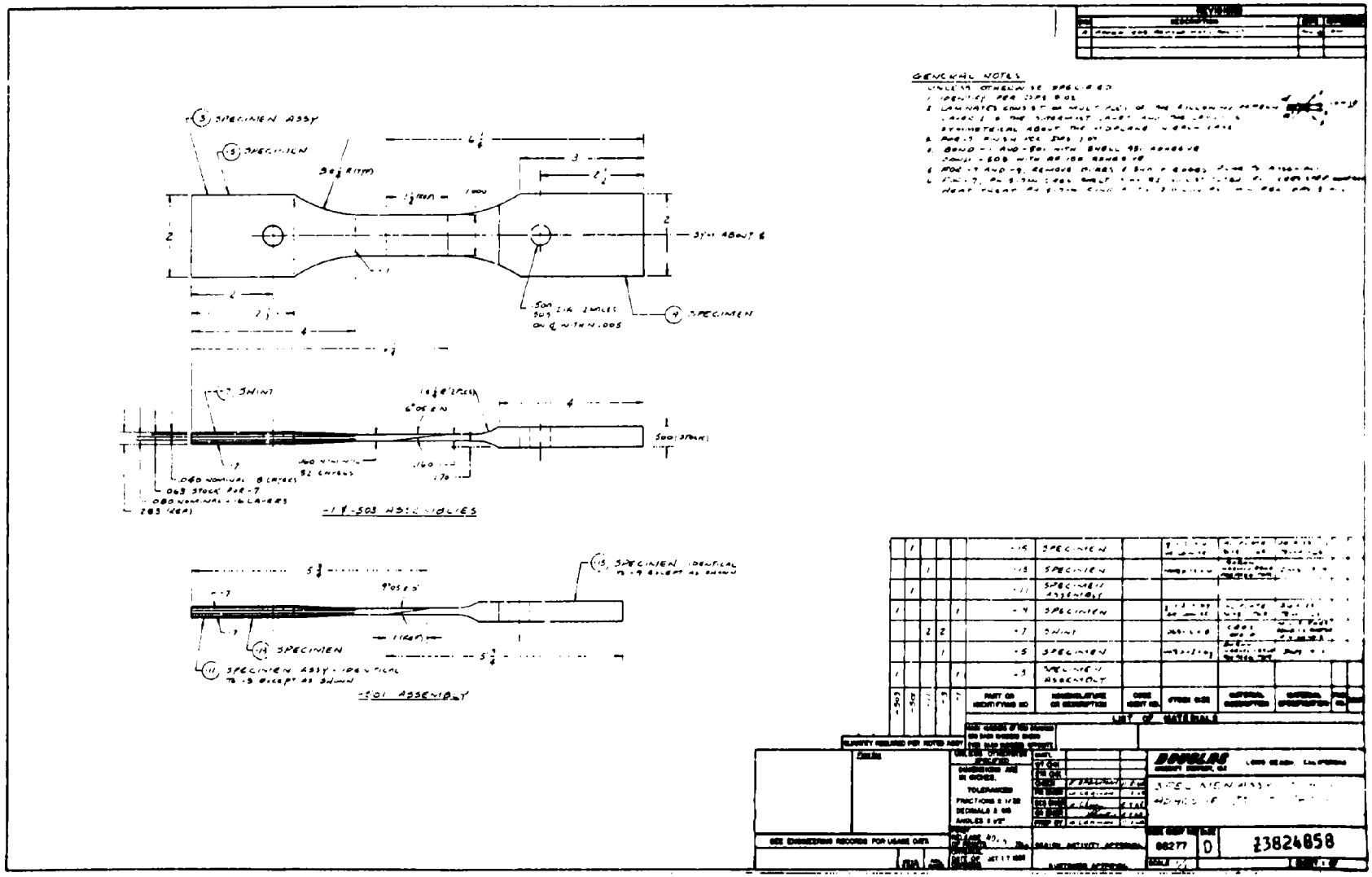
* STRESS RATIO, R = +0.05
SHELL 951 ADHESIVE

1 INCH SPECIMEN WIDTH
LAMINATE PATTERN A

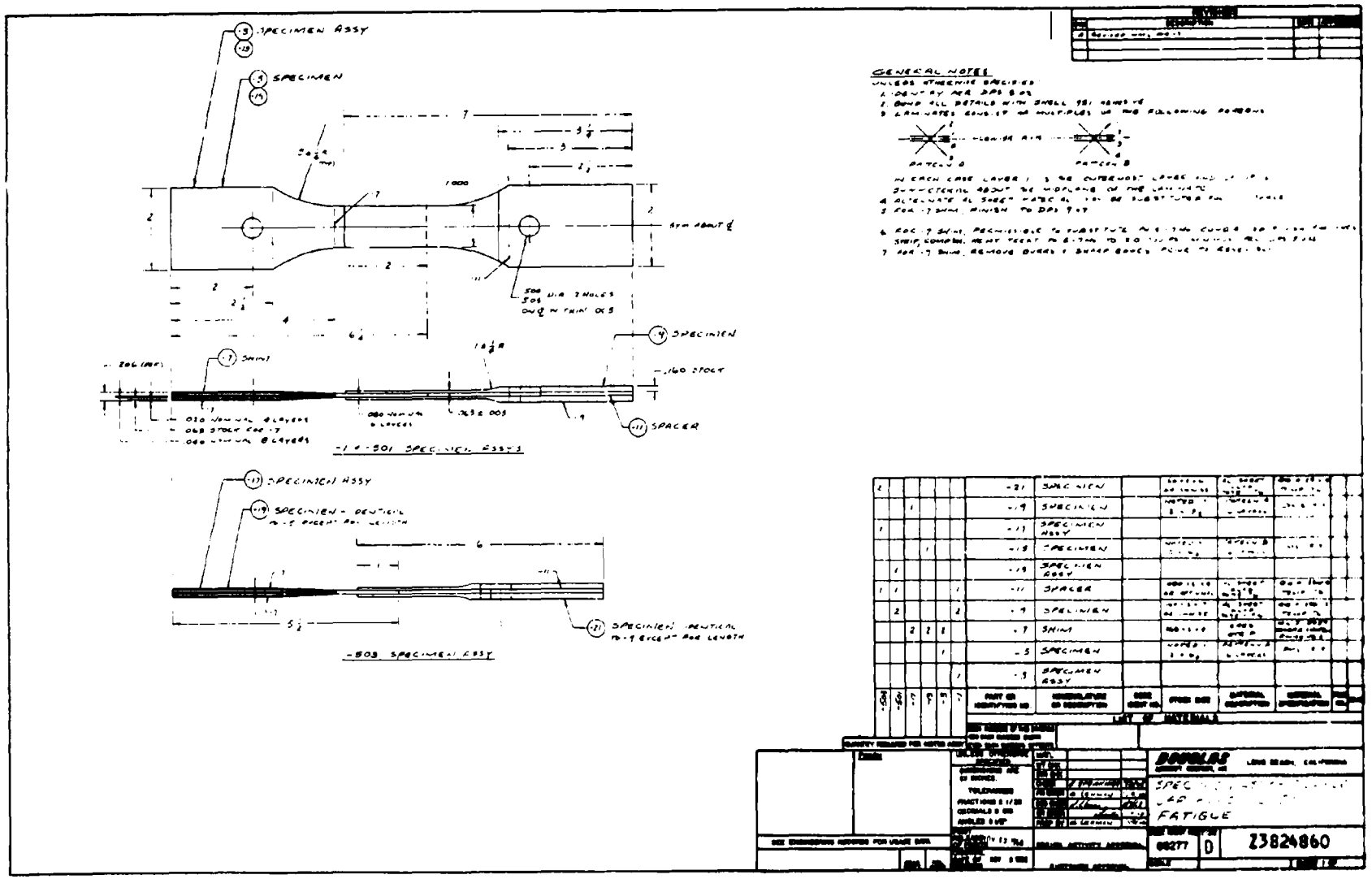
TABLE XVI
SUMMARY OF FATIGUE TEST RESULTS – JOINT CONCEPT SCREENING TESTS (Concluded)

JOINT TYPE	MATERIALS AND GAGES (IN.)	EDGE DISTANCE (IN.)	MAXIMUM LOAD / MINIMUM LOAD (LB)	MAXIMUM LOAD % OF STATIC ULTIMATE	TESTS	RANGE OF CYCLES TO FAILURE	FAILURE MODE
SINGLE LAP	BORON/BORON (0.120)/(0.120)	0.750	1800/90	70	5	4,000 TO 13,000	BEARING AND SHEAR-OUT
	BORON/7075-T6 (0.120)/(0.160)		1960/98	70	5	1,000 TO 24,000	BORON-BEARING ALUMINUM THROUGH FASTENER HOLE
	FIBERGLASS/ FIBERGLASS (0.120)/(0.120)		1460/73	70	5	1,700 TO 7,000	DELAMINATION AND SHEAR-OUT
	FIBERGLASS/7075-T6 (0.120)/(0.160)		1765/88	70	5	1,100 TO 62,700	DELAMINATION AND SHEAR-OUT
DOUBLE LAP	BORON/7075-T6 (0.120)/(0.200)		2100/105	70	5	130,000 TO 2,677,000	ALUMINUM THROUGH FASTENER HOLE NONE (RUNOUTS)
	FIBER GLASS/7075-T6 (0.120)/(0.200)		1650/83	70	3	1,000,000 TO 7,591,000	NONE (RUNOUTS)
			1890/95	80	2	1,247,000 TO 1,731,000	NONE (RUNOUTS) ALUMINUM THROUGH FASTENER HOLE
DOUBLE LAP BOLTED AND BONDED	BORON/7075-T6 (0.120)/(0.200)	0.750	4950/248	38	5	101,000 TO 176,000	LAMINATE AND ALUMINUM THROUGH HOLE ALUMINUM THROUGH BASIC SECTION
	FIBERGLASS/7075-T6 (0.120)/(0.200)		4950/248	66	5	11,400 TO 49,200	DELAMINATION AND ADHESIVE

*STRESS RATIO, R = +0.05
BOLT DIAMETER, D = 0.190 IN.
1-INCH SPECIMEN WIDTH
LAMINATE PATTERN A



DRAWING Z3824858. SPECIMEN ASSEMBLY – SCARF ADHESIVE JOINT FATIGUE



DRAWING Z3824860. SPECIMEN ASSEMBLY – DOUBLE LAP ADHESIVE JOINT FATIGUE

TABLE XVII
SUMMARY OF STATIC TEST RESULTS ON FATIGUE SPECIMEN JOINT CONFIGURATIONS

JOINT CONFIGURATION	STATIC TEST RESULTS ON FATIGUE SPECIMEN CONFIGURATION		
	ULTIMATE LOAD (LB)	AVERAGE ADHESIVE STRESS AT FAILURE (PSI)	AVERAGE ADHESIVE THICKNESS (IN.)
1-1/2-IN. SCARF	9175	5688	0.0030
BORON (PATTERN A)*	8900	5443	0.0030
TO ALUMINUM	9450	5363	0.0030
	8275	5052	0.0030
	AVG 8750	AVG 5386	AVG 0.0030
1-IN. SCARF	6100	5744	0.0030
BORON (PATTERN A)	6026	5579	0.0040
TO ALUMINUM	5200	4938	0.0030
	6550	6110	0.0030
	AVG 5969	AVG 5593	AVG 0.0032
2-IN. DOUBLE LAP	4650	1162	0.0020
BORON (PATTERN A)	4505(1)	1147	0.0020
TO ALUMINUM	5425	1340	0.0020
	6000(1)	1500	0.0020
	AVG 5185	AVG 1297	AVG 0.0020
2-IN. DOUBLE LAP	5500	1312	0.0020
BORON (PATTERN B)**	5495	1349	0.0020
TO ALUMINUM	4980	1205	0.0020
	4875	1157	0.0020
	AVG 5215	AVG 1256	AVG 0.0020
1-IN. DOUBLE LAP	6850(1)	3440	0.0020
BORON (PATTERN A)	5335(1)	2712	0.0020
TO ALUMINUM	6050(1)	3066	0.0020
	7825	3653	0.0020
	AVG 6515	AVG 3218	AVG 0.0020

(1) FAILED IN LAMINATE AT BASE OF REINFORCING SHIMS

*PATTERN A -- $0^\circ/45^\circ/-45^\circ/0^\circ$

**PATTERN B — $45^\circ/0^\circ/0^\circ/-45^\circ$

TABLE XVIII

SUMMARY OF S-n FATIGUE DATA*

SPECIMEN NUMBER	NOMINAL LAP LENGTH (IN.)	MAXIMUM FATIGUE LOAD (LB)	PERCENT OF STATIC LOAD	AVERAGE ADHESIVE STRESS AT MAXIMUM LOAD (PSI)	CYCLES TO FAILURE	FAILURE MODE**	RESIDUAL STRENGTH	
							ULTIMATE STRESS (PSI)	PERCENT OF STATIC LOAD
Z3824851-1 SCARF ($0^o/45^o/-45^o/0^o$)	1.5	5000	57	3340	12,000	3		
					42,000	3		
					44,000	3		
					150,000	3		
		4600	52.5	3100	85,000	3		
					95,000	3		
					132,000	1 & 3		
					880,000	3		
		4220	48	2830	17,000	3		
					189,000	1		
					191,000	1		
					1,000,000	RUNOUT	6835	127
		3830	43.7	2560	798,000	3		
					1,000,000	RUNOUT	6690	124
					1,039,000	RUNOUT	6250	116
					1,061,000	RUNOUT	6700	124
Z3824858-501 SCARF ($0^o/45^o/-45^o/0^o$)	1.0	3100	52	3110	57,000	3		
					96,000	3		
					926,000	3		
		2950	49.5	2970	19,000	2		
					34,000	2, 3		
					70,000	2		
					1,000,000	RUNOUT	6825	122
Z3824858-1	1.0	2800	47	2820	971,000	3		
		2670	45	2720	1,000,000	RUNOUT	6930	124
					1,000,000	RUNOUT	6910	124
					1,408,000	RUNOUT	6838	124
					1,674,000	RUNOUT	6460	116

*STRESS RATIO, R = + 0.05

**FAILURE MODES
(1) ALUMINUM ALLOY FAILED
(2) ADHESIVE OR COHESIVE
(3) INTERLAMINAR SHEAR
(4) COHESIVE ONE SIDE AND ALUMINUM ALLOY FAILURE OTHER SIDE

TABLE XVIII

SUMMARY OF Sn FATIGUE DATA* (Continued)

SPECIMEN NUMBER	NOMINAL LAP LENGTH (IN.)	MAXIMUM FATIGUE LOAD (LB)	PERCENT OF STATIC LOAD	AVERAGE ADHESIVE STRESS AT MAXIMUM LOAD (PSI)	CYCLES TO FAILURE	FAILURE MODE	RESIDUAL STRENGTH	
							ULTIMATE STRESS (PSI)	PERCENT OF STATIC LOAD
Z3824858-1 (CONTINUED)	1.0	2340	39	2360	1,000,000	RUNOUT	6560	118
					1,000,000	RUNOUT	6180	109
					1,000,000	RUNOUT	6875	120
					7,018,000	RUNOUT	6720	120
Z3824860-1 DOUBLE LAP $(0^o/45^o/-45^o/0^o)$	2.0	4750	92	1200	1000	2		
					1000	2		
		3200	62	805	48,000	2		
					54,000	4		
		2850	55	723	95,000	4		
					116,000	2		
					120,000	2		
					295,000	2		
		2325	45	586	263,000	4		
					318,000	4		
					447,000	4		
					660,000	1		
		1900	37	480	617,000	1		
					720,000	1		
					1,045,000	4		
					1,000,000	RUNOUT	1500	115
Z3824860-501 DOUBLE LAP $(45^o/0^o/0^o/-45^o)$	2.0	2850	55	720	1,000	3		
					3,000	3		
		2300	44	577	18,000	3		
					34,000	3		
					34,000	3		
					165,000	3		
		2100	40	532	26,000	3		
					33,000	3		

*STRESS RATIO, R = +0.05

TABLE XVIII

SUMMARY OF S-n FATIGUE DATA* (Concluded)

SPECIMEN NUMBER	NOMINAL LAP LENGTH (IN.)	MAXIMUM FATIGUE LOAD (LB)	PERCENT OF STATIC LOAD	AVERAGE ADHESIVE STRESS AT MAXIMUM LOAD (PSI)	CYCLES TO FAILURE	FAILURE MODE	RESIDUAL STRENGTH	
							ULTIMATE STRESS (PSI)	PERCENT OF STATIC LOAD
Z3824880-501 (CONTINUED)	2.0	1900	36	480	46,000	3		
					52,000	3		
					1,575,000	1, 3		
					1,000,000	RUNOUT	1784	142
		1600	31	402	364,000	1, 3		
					1,001,000	RUNOUT	1020	81
					1,293,000	RUNOUT	1235	98
Z3824880-503 DOUBLE LAP ($0^{o}/45^{o}/-45^{o}/0^{o}$)	1.0	2200	34	1110	19,000	2		
					29,000	2		
					30,000	2		
					84,000	2		
		1900	29	960	64,000	2		
					74,000	2		
					101,000	2		
					1,000,000	RUNOUT	3000	93
		1650	24	780	1,000,000	RUNOUT	2900	90
					1,400,000	RUNOUT	3490	108
					1,542,000	RUNOUT	3670	114
		1200	18	610	1,000,000	RUNOUT	3560	111
					1,000,000	RUNOUT	3770	117
					1,017,000	RUNOUT	3935	122
					1,142,000	RUNOUT	2381	74

*STRESS RATIO, R = +0.05

SECTION III
QUALITY CONTROL DATA

QUALITY CONTROL DATA

MATERIAL SPECIFICATION, INCOMING INSPECTION, AND QUALITY CONTROL RECORDS

The materials data and joint specimens were made from prepregged "B"-staged boron tapes or S-994 fiber glass roving using the Narmco 5505 epoxy resin system. The boron tapes were purchased under material specification DMS 1919 A, "Boron Filament Tape, Organic Resin Impregnated," from the Whittaker Corporation, Narmco Materials Division. This specification is included at the end of this section. The S-994 fiber glass roving was impregnated by the U. S. Polymeric Company, using bulk 5505 resin purchased from Narmco. A specification was not established for this material, but incoming inspection tests were conducted on each shipment of material before it was used in specimens. These incoming inspection records, together with in-process quality control records, are presented in this appendix.

Raw materials used in the program were procured to the following specifications and purchase order requirements.

MATERIAL	REQUIREMENTS
BORON/5505 RESIN	DMS 1919A
FIBER GLASS/5505 RESIN	PURCHASE ORDER
SHELL 951 ADHESIVE	DMS 1808
3M COMPANY – AF130 ADHESIVE	PURCHASE ORDER
3M COMPANY – AF1108 ADHESIVE	PURCHASE ORDER
NARMCO 252 ADHESIVE	DMS 1911
BLOOMINGDALE RUBBER COMPANY HT 424 ADHESIVE	DMS 1769
LEFKOWELD-109 ADHESIVE	PURCHASE ORDER

Each purchase of boron and fiber glass prepreg was identified by the supplier, with lot and unit numbers directly traceable to his process run. In addition, the identity of the lot was recorded for each specimen fabricated throughout the program. This information is summarized in Table XIX. Reproductions of the Quality Control Receiving Inspection Reports are included herein for each lot of prepregged material received during the program.

TABLE XIX
MATERIAL RECEIPT AND USAGE

MATERIAL AND LOT NUMBER		PURCHASE ORDER NUMBER	DATE RECEIVED	AMOUNT RECEIVED		SPECIMEN TRACEABILITY
				FEET	POUNDS	Z3824815 Z3824816 Z3824817 Z3824818 Z3824824 Z3824825 Z3824827 Z3824828 Z3824829 Z3824830 Z3824831 Z3824832 Z3824833 Z3824834 Z3824838 Z3824839 Z3824840 Z3824841 Z3824842 Z3824843 Z3824849 Z3824850 Z3824851 Z3824852 Z3824854 Z3824855 Z3824856 Z3824858 Z3824860
BORON-3505 RESIN	LOT 219	7C1 366289	5/23/67	1000 (1/8 IN.)	0.6	x
	LOT 220	7C1 366289	5/23/67	660	9.6	x x x x x x x x
	LOT 248	7C1 366289	9/13/67	1592*	23.6	
	LOT 249	7C1 366289	2/29/67	670	9.6	x x x x x
		7C1 366342	9/29/67	225	3.2	
	LOT 262	7C1 366289	12/1/67	2733	38.9	x x x x x x x x x x
	LOT 268	7C1 472664	1/26/68	238	3.4	x
	LOT 278	BCY-637813	3/28/68	1726	24.0	x x x x
	LOT 282	BCY-637813	4/3/68	486	6.9	x x
		BCY 637812	4/22/68	349	4.9	
	LOT 285	BCY-687095	5/22/68	2138	31.8	x x x x x x x x x x x x
	LOT 297	NONE	11/19/68	622	8.0	x x
S-994 GLASS-3505 RESIN	LOT 2236	7C1 472563	12/9/67	NOT APPLICABLE	49.3	
	LOT 2254	BCY 637643	3/9/68	NOT APPLICABLE	31.1	
	LOT 2256	BCY 637823	4/2/68	NOT APPLICABLE	52.0	
	LOT 2270	BCY-687605	6/24/68	NOT APPLICABLE	32.2	

*REJECTED AND RETURNED TO VENDOR FOR FULL CREDIT.

All material received was tested for conformance to the requirements of the appropriate specification and/or purchase order. The boron and glass prepreg was fabricated into small, unidirectional panels and tested as indicated in Table XX. Adhesive quality was ascertained by the preparation and testing of tensile lap shear specimens using boron and aluminum alloy adherends. The layups and cure cycles employed for receiving tests are detailed in Table XXI. Tables XXII through XXIV are summaries of the test results for boron, glass, and adhesives, respectively.

In-process quality control lap shear test coupons were cured concurrently with the joint specimens as a means of assuring both the quality of the adhesive and the effectiveness of the bonding cycle. The results of the tensile testing of these control coupons are summarized in Table XXV. Aluminum alloy 7075-T6 adherends were used in these specimens.

TABLE XX
QUALITY CONTROL TESTS AND METHODS

PROPERTY	TEST METHOD	TEST DESCRIPTION
PREPREG RESIN CONTENT	BORON – DMS 1919A GLASS – BURNOUT	SOLVENT EXTRACTION 45 MIN AT 1450°F
VOLATILE CONTENT	DMS 1919A	15 MIN AT 300°F CIRCULATING AIR
FLEXURAL STRENGTH	DMS 1919A	ASTM-D790 FOR BORON AND GLASS – 3 POINT LOADING
FLEXURAL MODULUS	DMS 1919A	ASTM-D790 FOR BORON AND GLASS – 3-POINT LOADING
HORIZONTAL SHEAR	DMS 1919A	ASTM-D-PROPOSED – FOR BORON AND GLASS
LAMINATED RESIN CONTENT	BORON – DMS 1919A GLASS – BURNOUT	VACUUM PYROLYSIS 45 MIN AT 1450°F
DENSITY	ASTM D792-64T	DISPLACEMENT OF WATER
VOID CONTENT	ASTM D2734	CALCULATED USING RESIN CONTENT AND DENSITY

TABLE XXI
QUALITY CONTROL SPECIMEN LAYUPS AND CURE CYCLES

MATERIAL	LAYUP	CURE CYCLE	POST CURE
BORON/5505 RESIN	UNIDIRECTIONAL 15 PLY	2 HR, 200°F, 100 PSI 2 HR, 300°F, 100 PSI	1 HR, 350°F
GLASS/5505 RESIN	UNIDIRECTIONAL 12 PLY	2 HR, 200°F, 100 PSI 2 HR, 300°F, 100 PSI	1 HR, 350°F
SHELL 951 ADHESIVE	LAP SHEAR ALUMINUM ADHEREND	1 HR, 350°F, 50 PSI	NONE
3M COMPANY – AF130 ADHESIVE		1 HR, 350°F, 50 PSI	
3M COMPANY – AF1108 ADHESIVE		1 HR, 350°F, 50 PSI	
NARMCO 252 ADHESIVE		1-1/2 HR, 250°F, 50 PSI	
BLOOMINGDALE RUBBER COMPANY HT 424 ADHESIVE		1 HR, 350°F, 50 PSI	
LEFKOWELD – 109 ADHESIVE		1 WEEK, ROOM TEMP CONTACT PRESSURE	

TABLE XXII

SUMMARY OF RECEIVING QUALITY CONTROL TESTING OF BORON PREPREG

PROPERTY	LOT 219*	LOT 220	LOT 249	LOT 262	LOT 268	LOT 278	LOT 282	LOT 285	LOT 297
1. RESIN CONTENT (%)									
a. AVG FOR LOT	29.4	30.8	30.4	32.4	29.6	32.3	32.2	33.5	33.5
b. NO. ROLLS TESTED	2	4	1	10	4	4	7	3	2
c. RANGE	29.1 – 29.7	29.6 – 32.7	–	30.0 – 36.0	29.0 – 30.6	30.5 – 33.3	31.1 – 33.3	33.2 – 33.7	32.6 – 34.4
2. VOLATILE CONTENT (%)									
a. AVG FOR LOT	0.78	1.00	0.91	1.22	1.36	0.94	1.44	0.95	0.46
b. NO. ROLLS TESTED	2	3	1	9	4	4	7	3	2
c. RANGE	0.48 – 1.08	0.60 – 1.20	–	0.32 – 1.33	1.17 – 1.47	0.60 – 1.37	1.06 – 1.71	0.55 – 1.25	0.40 – 0.53
3. FLEXURAL STRENGTH (PSI)									
a. AVG FOR LOT	284,000	269,100	255,800	256,600	247,800	259,500	280,300	257,600	297,900
b. NO. ROLLS TESTED	1	1	1	2	1	1	1	1	2
4. FLEXURAL MODULUS (PSI)									
a. AVG FOR LOT x 10^6	28.8 (35.0)**	34.9	23.4 (31.2)**	24.8 (32.2)**	23.1 (30.8)**	29.5	31.1	28.8	33.8
b. NO. ROLLS TESTED	1	1	1	2	1	1	1	1	2
5. HORIZONTAL SHEAR (PSI)									
a. AVG FOR LOT	7,700†	NOT TESTED††	8,000†	8,440†	7,800†	9,370	9,050	9,520	8,890
b. NO. ROLLS TESTED	1		1	2	1 1	1	1	1	2
6. LAMINATE RESIN CONTENT (%)									
a. AVG FOR LOT	NOT TESTED	NOT TESTED	20.8	23.3	21.6	23.0	23.6	27.0	20.6
b. NO. ROLLS TESTED			1	2	1	1	1	1	2
7. DENSITY									
a. AVG FOR LOT	NOT TESTED	NOT TESTED	2.0320	1.9880	2.0238	2.0455	2.0298	1.9920	1.9930
b. NO. ROLLS TESTED			1	2	1	1	1	1	2
8. VOID CONTENT (VOL %)									
a. AVG FOR LOT	NOT TESTED	NOT TESTED	4.90	6.00	4.53	2.67	2.48	1.29	6.82
b. NO. ROLLS TESTED			1	2	1	1	1	1	2

*1/8-INCH BORON **ESTIMATED VALUE FOR 32:1 SPAN RATIO †7:1 SPAN RATIO USED ††VENDOR TESTING ACCEPTED

TABLE XXIII
SUMMARY OF RECEIVING QUALITY CONTROL TESTING OF FIBER GLASS PREPREG

PROPERTY	LOT F2238	LOT F2254	LOT F2256	LOT F2270
1. RESIN CONTENT (%)				
a. AVG FOR LOT	28.8	29.6	28.4	24.0**
b. NO. ROLLS TESTED	5	7	3	5
c. RANGE	24.4* – 31.0	27.0 – 31.7	27.4 – 29.1	21.8 – 30.7**
2. VOLATILE CONTENT (%)				
a. AVG FOR LOT	0.42	0.48	0.24	0.76**
b. NO. ROLLS TESTED	5	7	3	5
c. RANGE	0.37 – 0.48	0.36 – 0.68	0.13 – 0.38	0.7 – 0.9
3. FLEXURAL STRENGTH (PSI)				
a. AVG FOR LOT	206,500	299,200	267,000	249,800
b. NO. ROLLS TESTED	1	1	1	1
4. FLEXURAL MODULUS (PSI)				
a. AVG FOR LOT x 10^6	7.1	9.1	8.7	9.1
b. NO. ROLLS TESTED	1	1	1	1
5. HORIZONTAL SHEAR (PSI)				
a. AVG FOR LOT	9,180	9,130	7,840	9,500
b. NO. ROLLS TESTED	1	1	1	1
6. LAMINATE RESIN CONTENT (%)				
a. AVG	24.6	19.3	18.9	20.2
b. NO. ROLLS TESTED	1	1	1	1
7. DENSITY				
a. AVG FOR LOT	1.987	2.059	2.061	1.994
b. NO. ROLLS TESTED	1	1	1	1
8. VOID CONTENT (VOL %)				
a. AVG	0.72	0.30	1.4	3.49
b. NO. ROLLS TESTED	1	1	1	1

*RESULTS LOW DUE TO NO "END" SAMPLE
**VENDOR TESTING

TABLE XXIV
SUMMARY OF ADHESIVE TEST RESULTS FOR BORON LAMINATED TO ALUMINUM ALLOY

ADHESIVE	DOUBLE LAP TENSILE SHEAR			MODE OF FAILURE	
	REPLICATES	AVERAGE (PSI)	RANGE (PSI)		
3M COMPANY – AF130	5	1,125*	962 – 1272	GLASS SCRIM SURFACE OPPOSITE SURFACE	100% RESIN TO BORON FIBER EXPOSING BARE BORON 100% RESIN TO BORON FIBER EXPOSING BARE BORON
3M COMPANY – AF1108	5	4,374	4,038 – 4,740	GLASS SCRIM SURFACE OPPOSITE SURFACE	75% COHESIVE – 25% RESIN TO BORON FIBER EXPOSING BARE BORON 75% COHESIVE – 25% MATRIX RESIN TO BORON FIBER EXPOSING BARE BORON
NARMCO – 252	5	4,847	4,036 – 5,614	GLASS SCRIM SURFACE OPPOSITE SURFACE	50% ADHESIVE TO LAMINATE – 50% RESIN TO BORON FIBER EXPOSING BARE BORON 100% ADHESIVE TO LAMINATE
BLOOMINGDALE RUBBER COMPANY HT 424	5	1,492**	1,066 – 2,043	GLASS SCRIM SURFACE OPPOSITE SURFACE	75% ADHESIVE TO LAMINATE – 25% RESIN TO BORON FIBER EXPOSING BARE BORON 25% ADHESIVE TO LAMINATE – 75% RESIN TO BORON FIBER EXPOSING BARE BORON
LEFKOWELD – 109	5	1,880	1,562 – 2,244	GLASS SCRIM SURFACE OPPOSITE SURFACE	100% ADHESIVE TO LAMINATE 80% COHESIVE – 20% ADHESIVE TO ALUMINUM
SHELL – 951	5 5***	5,601 5,432	5,280 – 5,950 5,273 – 5,606	GLASS SCRIM SURFACE OPPOSITE SURFACE	10% ADHESIVE TO LAMINATE – 90% RESIN TO BORON FIBER EXPOSING BARE BORON 50% COHESIVE – 50% ADHESIVE TO LAMINATE

*TAKEN FROM MATERIAL BATCH WITH 3000 PSI MINIMUM ALUMINUM-TO-ALUMINUM SHEAR
**TAKEN FROM PRODUCTION APPROVED MATERIAL WITH 2800 PSI MINIMUM ALUMINUM-TO-ALUMINUM SHEAR
***SINGLE LAP TENSILE SHEAR

TABLE XXV
SUMMARY OF IN-PROCESS TESTING OF CONTROL COUPONS
(ADHESIVE AND BONDING EFFICIENCY)

BOND CYCLE	NUMBER OF TESTS	SHEAR STRESS		ADHESIVE
		AVERAGE	RANGE	
Z3824827	5	6,965	6804-7219	SHELL 951
Z3824828	5	7,052	6528-7486	SHELL 951
	5	2,914	2812-3030	AF130
Z3824829	5	5,694	5482-5942	SHELL 951
Z3824830	5	5,414	4712-6545	SHELL 951
Z3824850	5	6,042	5870-6627	SHELL 951
Z3824854	5	5,536	5067-5837	SHELL 951
Z3824855	5	6,666	6407-6893	AF130 AND SHELL 951
Z3824858	5	4,317	4194-4426	SHELL 951
Z3824858	5	5,247	5058-5472	SHELL 951
Z3824858	5	5,536	5069-5837	SHELL 951
Z3824860	5	6,629	6006-6769	SHELL 951

BORON FILAMENT TAPE, ORGANIC RESIN IMPREGNATED

1. SCOPE

1.1 Scope - This specification covers continuous boron filament tape, organic resin impregnated.

1.2 Classification

1.2.1 Continuous boron filament tape, organic resin impregnated shall consist of the types shown in Table 1.

TABLE 1

TAPE CLASSIFICATION

TYPE	MAXIMUM WIDTH (INCHES)	NUMBER OF FIBERS PER INCH OF WIDTH	CONSTRUCTION	CARRIER	MINIMUM LENGTH
1	3.0	208 to 224	Boron-Glass Spaced	E Glass Fiber or S Glass Fiber Yarns	60 Feet
2	3.0	208 to 224	All Boron-Resin Pre-coat Optional	None	60 Feet
3	3.0	208 to 224	All Boron-Resin Pre-coat Optional	104 E-Glass Cloth or Meltable Scrim	60 Feet

2. APPLICABLE DOCUMENTS

2.1 The following specifications and standards (and subsidiaries thereof), drawings and publications of the issue in effect on date of invitation for bid, except as otherwise noted or controlled on an individual basis, form a part of this specification to the extent specified herein.

SPECIFICATIONS

Military

MIL-Y-1140 Yarn, Cord, Sleeving, Cloth, and Tape Glass

STANDARDS

Military

MIL-STD-129 Marking for Shipment and Storage

2.1 (Cont'd)

OTHER PUBLICATIONS

AMERICAN SOCIETY FOR TESTING AND MATERIALS

ASTM D 618		Methods of Conditioning Plastics and Electrical Insulating Materials for Testing
ASTM D 790		Method of Test for Flexural Properties of Plastics
ASTM D 20	(Unassigned)	** Proposed Method of Test for Apparent Horizontal Shear Strength of Flat Laminates
ASTM D	(Unassigned)	** Proposed Method of Test for Void Content of Reinforced Plastics
ASTM D	(Unassigned)	** Proposed Method of Test for Tensile Properties of Highly Oriented Reinforced Plastics
ASTM D	(Unassigned)	** Proposed Method for the Determination of the Ultimate Tensile Strength of Single Boron Fibers at Room Temperature and Elevated Temperatures
ASTM D	(Unassigned)	** Proposed Method of Test for the Determination of Organic Resin Content in a Boron Filament Reinforced Plastic Composite

** NOTE: ASTM 1967 Index of Standards - Proposed methods, although not officially accepted by the ASTM as a body, do have the authorization of the sponsoring committee D20. Copies of these test methods are available upon request from Materials & Process Engineering, CI-260.

3. REQUIREMENTS

3.1 Preproduction Approval - The material furnished under this specification shall be a product which has passed the preproduction tests specified in Tables 2 and 3. After preproduction approval, the properties and methods of manufacture shall not be changed without written approval from the procuring activity.

3.1.1 Preproduction Sample - Unless otherwise specified by the procuring activity, the supplier shall furnish samples of the material for preproduction tests, in accordance with the following requirements:

3.1.1.1 The preproduction sample shall consist of the "B" Stage material selected, as indicated in paragraph 4.1.6. From the sample selected, specimens for tests specified in Tables 2 and 3, shall be prepared and tested.

3.1.1.2 The preproduction samples shall be identified with the same markings used for the lot represented.

3.2 Production Approval - The material furnished under this specification shall be a product which has passed as required the production tests specified in Tables 2 and 3.

3.2.1 Production Sample - Unless otherwise specified by the procuring activity, the supplier shall furnish samples of the material for production tests, in accordance with the following requirements:

3.2.1.1 The production sample shall consist of the "B" Stage material selected, as indicated in paragraph 4.1.6. From the sample selected, specimens for tests specified in Tables 2 and 3, shall be prepared and tested.

3.2.1.2 The production samples shall be identified with the same markings used for the lot represented.

3.3 Component Requirements

3.3.1 Resin - The organic resin shall, when reinforced with the continuous boron filaments, meet the requirements of Tables 2 and 3.

3.3.2 Continuous Boron Filaments - The continuous boron filaments shall be 0.0040" ± .0001" diameter. When tested in accordance with ASTM D ** Proposed, "Method for the Determination of the Ultimate Tensile Strength of Single Boron Fibers at Room Temperature and Elevated Temperatures", the boron filaments shall have a minimum tensile strength of 400,000 psi and a minimum modulus of elasticity of 55×10^6 psi at room temperature.

3.3.2.1 Splices - The minimum allowable distance between splices shall be 800 ft. No more than five splices in a 20,000 ft. roll shall be permitted.

3.3.3 Carrier (Scrim) - Where specified by the procuring activity, the tape shall be furnished with a carrier able to support the boron fibers during processing and maintain filament spacing parallelism, and orientation during storing and handling. The carrier shall be as specified in Table 1.

3.3.3.1 Glass Carrier - The glass carrier shall meet the requirements of 104E glass cloth, and shall have a finish compatible with the resin system used.

3.3.4 Glass Fiber Yarns - The glass yarns used in the scrim carrier for the boron tape shall meet the requirements of MIL-Y-1140, Class C, Form 1, E-glass.

3.4 Tape Requirements and Properties

3.4.1 Construction - The tape shall consist of parallel, continuous boron filaments. Filaments crossing over another shall not be permitted. Spacing and number of filaments required are detailed in paragraph 3.4.2; other detailed construction information listed in Table 1.

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3.4.2 Number of Boron Filaments Per Inch and Spacing - The tape shall be composed of 208 to 224 filaments per inch of width. The boron filaments shall be spaced as follows:

a. Not more than 2% shall be spaced less than 0.0002".

b. Not more than 89% shall be spaced between 0.0002" and 0.0012".

c. Not more than 10% shall be spaced greater than 0.0012".

d. Not more than 5% shall be spaced greater than 0.002".

e. Not more than 2% shall be spaced greater than 0.010".

f. Not more than .5% shall be spaced greater than 0.015".

3.4.3 Width and Length - The width and length of the tape shall be as specified by the procuring activity. Minimum length of tape shall be per Table I, except for one roll in any one shipment. The specified width of the tape shall be uniform from one end to the other in any roll. Maximum variation allowed shall be one-half of one percent of the specified width, as determined with a noncontact measurement apparatus. No more than two such variations per linear foot, in any one roll shall be allowed.

3.4.3.1 Broken Filaments - Breaks on adjacent filaments on the tape, situated one-half inch of each other, shall not be permitted.

3.4.4 Uniformity and Orientation - The filaments on the tape shall be uniformly and directionally oriented.

3.4.4.1 Room Temperature Working Life - The material must be capable of meeting the requirements of this specification after exposure to room temperature (80°F max.) for up to 200 hours.

3.4.5 General Handling Characteristics - Material shall permit for easy removal of the separator band when chilled without losing resin, tearing, shredding, or otherwise becoming damaged. The material shall be capable of being cut without disarray of the boron filaments or visible damage which will render the tape useless.

3.4.6 Storage Life - The material shall satisfy the requirements of this specification a minimum of ninety days after impregnation date when packaged and packed in conformance to paragraphs 5.1 and 5.1.2, and shipped and stored in a temperature environment specified in paragraphs 5.4 and 5.5.

3.4.7 Properties - Unless otherwise specified by the procuring activity, the properties of the preimpregnated "B" Stage tape shall conform to the requirements of Table 2. The properties of the cured material shall conform to the requirements of Table 3.

3.4.8 Quality Control - The supplier shall maintain throughout the entire processing of the tape, all necessary quality controls and inspections of basic materials to demonstrate conformance to the requirements of this specifications.

3.4.9 Workmanship - The boron tape shall be of the highest quality of workmanship and shall be free from excess resin accumulations, starved areas, blisters, foreign materials, and other defects, except as specifically agreed or permitted by the procuring activity, and verified by a visual inspection.

TABLE 2

PREIMPREGNATED "B" STAGE MATERIALS

PROPERTY REQUIREMENTS AND TEST METHODS

PROPERTY	REQUIREMENT	PREPRODUCTION METHOD OF TEST (PARAGRAPH)	PRODUCTION METHOD OF TEST (PARAGRAPH)
Volatiles Content (% by Wt.)	2.0 max.	4.2.4.2	4.2.4.2
Wet Resin Content (% by Wt.)	32 ± 3	4.2.4.3	4.2.4.3
Filament Count	208 to 224	4.2.4.4	4.2.4.4
Filament Spacing	Per paragraph 3.4.2	4.2.4.5	Not Required

TABLE 3

CURED MATERIAL PROPERTY REQUIREMENTS
AND METHODS OF TEST

MECHANICAL PROPERTY	REQUIREMENT	PREPRODUCTION METHOD OF TEST (PARAGRAPH)	PRODUCTION METHOD OF TEST (PARAGRAPH)
Ultimate Flexural Strength psi, Min.	225,000	4.2.5.1	4.2.5.1
Flexural Modulus psi, Min.	26.0×10^6	4.2.5.1	4.2.5.1
Ultimate Tensile Strength psi, Min.	180,000	4.2.5.2	Not Required
Tensile Modulus psi, Min.	33×10^6	4.2.5.2	Not Required
Ultimate Horizontal Shear Strength psi, Min.	8,500	4.2.5.3	4.2.5.3
Laminate Resin Content Leco Process (% by Wt.)	25 ± 3	4.2.5.4	4.2.5.4
Void Content (% by Vol.) Max.	2.0	4.2.4.3	4.2.4.3

4. QUALITY ASSURANCE PROVISIONS

4.1 Inspection and Test Requirements - The supplier shall be responsible for the performance of all tests and inspection requirements as specified by the procuring activity. Except as otherwise specified, the supplier may utilize his own or any other inspection facilities and testing laboratory services acceptable to the procuring activity.

4.1.1 Inspection Records - Inspection records shall be kept by the supplier, complete and available to the procuring activity, as specified by the contract or order, where such inspections are deemed necessary to assure that supplies and services conform to the prescribed requirements.

4.1.1.1 Certification - Every lot of material covered by this specification shall be certified by the supplier stating that the components (boron filaments, resin, and glass carrier) and processing used in the manufacture of the tape are similar to those used for the production sample.

4.1.2 Roll - A roll of material shall be defined as a continuous length of tape, contained on a spool.

4.1.3 Lot - A lot shall consist of material produced in one manufacturing cycle, under substantially indentical conditions, and offered for acceptance at one time. Lot numbers shall be designated by the supplier.

4.1.4 Processing Data - "B" Stage Material - The supplier shall furnish the required processing data with each lot of "B" Stage material, including curing and postcure schedules, temperatures, and pressure conditions.

4.1.5 Test Reports - With each lot, the supplier shall furnish a report stating the quantitative results of tests and inspections performed on representative samples. Both individual and average tests results shall be included. The report shall include all necessary identification to correlate the inspections and test results with the lot of material and the purchase order or contract. Deviations from this specification in specimen preparation or testing procedures shall be reported and fully explained.

4.1.6 Sampling Plan - Sampling shall be accomplished in accordance with Table 4.

TABLE 4

MINIMUM SAMPLING FREQUENCY

PROPERTY	SAMPLING FREQUENCY	
	Per Lot	Per Roll
Volatile Content	X	
Wet Resin Content		X
Filament Count		X
Filament Spacing	X	
Ultimate Flexural Strength	X	
Flexural Modulus	X	
Ultimate Tensile Strength	X	
Tensile Modulus	X	
Ultimate Horizontal Shear Strength	X	
Laminate Resin Content	X	
Void Content	X	

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4.1.6.1 Procedure - Remove roll of tape from cold storage, keep in moisture proof plastic bag, and allow to come to room temperature for a minimum of three hours.

4.1.6.2 Remove roll from moistureproof plastic bag.

4.1.6.3 Cut enough tape from roll to conduct tests.

4.1.6.4 Replace plastic bag and reseal. Replace sealed roll in cold storage. Samples taken, if not used immediately shall be wrapped and sealed in a moisture-proof bag and refrigerated until used.

4.1.6.5 Test specimens shall be fabricated, and all required tests initiated within 12 hours of sampling.

4.1.7 Rejections - Material not conforming to the specified requirements or to authorized written changes, or modifications, shall be subject to rejection.

4.1.8 Defects - Defects not detected during lot acceptance testing, apparent during use shall be cause for rejection of the unused portion of the roll provided such defect is cause for rejection under the requirements of this specification and is not a result of mishandling, improper storage, or expiration of shelf life.

4.1.9 Retests - Rejected material may be reworked to correct defects, and resubmitted for retest. The resubmitted material shall be accompanied by the data concerning previous rejection, and the action taken to correct the defects. Material rejected on retest shall not be submitted again without the authorization of the procuring activity.

4.2 Tests Methods and Procedures

4.2.1 Classification - The test methods and procedures for the verification of the requirements of the boron tape shall be classified as follows: Preproduction and Production Test Methods.

4.2.2 Preproduction Test - The preproduction tests shall consist of all tests listed in Tables 2 and 3.

4.2.3 Production Test - The production tests shall consist of all tests listed in Tables 2 and 3 as production tests. Unless otherwise specified by the procuring activity, all material procured under this specification shall pass the production tests specified, prior to shipment to the procuring activity.

4.2.4 Methods of Test for Preimpregnated "B" Stage Material - The methods of test for preimpregnated "B" Stage material shall consist of the following:

4.2.4.1 Volatile Content - The volatile loss percent by weight of the "B" Staged boron tape shall be determined as follows:

4.2.4.1.1 Cut from the sample, three 3" ± 1/16" square specimens.

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4.2.4.1.2 Weigh to the nearest 0.001 gram. Record the weight as W_1.

4.2.4.1.3 Suspend the specimens on a removable tray (areas of tray in contact with specimens shall be covered with a parting film such as Mylar or Teflon) in a circulating air oven preheated at 149° ± 6°C (300° ± 10°F).

4.2.4.1.4 Expose the specimens to 149°C (300°F) for 15 minutes ± 1 minute. Remove the tray from the oven.

4.2.4.1.5 Remove specimens from tray and place in a desiccator.

4.2.4.1.6 Cool specimens to room temperature inside desiccator for 30 minutes. Remove from desiccator and reweigh. Record as W_2.

4.2.4.1.7 Calculate volatile loss percent as follows:

$$\text{Volatile Content Percent} = \frac{W_1 - W_2}{W_1} \times 100$$

Where: W_1 = Original weight of sample, grams

W_2 = Final weight of sample, grams

4.2.4.1.8 Calculate the arithmetic mean of three determinations as volatile content of the sample.

4.2.4.2 Wet Resin Content (Solvent Process) - The percent of resin content (organic matter) by weight shall be determined as follows:

4.2.4.2.1 Cut from the sample, three 3" ± 1/16" square specimens. Weigh to the nearest 0.001 gram, and record as W_1.

4.2.4.2.2 Wash specimens in boiling solvent for two minutes. Time starts when the solvent starts to boil. Decant the solvent. The solvent used shall be capable of completely dissolving the resin under the conditions of this test.

4.2.4.2.3 Repeat steps in paragraph 4.2.4.2.2 for three complete wash cycles.

4.2.4.2.4 Dry specimens one hour at 163°C (325°F) and cool in a desiccator.

4.2.4.2.5 Remove specimens from desiccator after 10 ± 1 minute and weigh to the nearest 0.001 gram. Record as weight W_3.

4.2.4.2.6 Calculate resin content percent by weight as follows:

$$\text{Wet Resin Content Percent by Weight} = \frac{W_1 - W_3}{W_3} \times 100$$

Where: W_1 = Original weight of sample, grams

W_3 = Final weight of sample, grams

4.2.4.2.7 Calculate the arithmetic mean of three determinations as wet resin content of the sample.

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4.2.4.3 Void Content - The void content of the material shall be determined in accordance with ASTM **Proposed, "Method of Test for Void Content of Reinforced Plastics".

4.2.4.4 Filament Count - The filament count shall be determined by counting the filaments across the full width of the roll using any suitable technique.

4.2.4.5 Filament Spacing - Spacing shall be determined as follows:

4.2.4.5.1 Apparatus - Nikon Profile Projection, Model 6C - or equivalent
Nikon Polaroid Film - Holder 3-1/2 x 4-1/2 - or equivalent

4.2.4.5.2 Cut a template 6" ± 1/8" long, and as wide as the specimen tested, make three 1/4" diameter holes on template placed at the quarter and midpoints on the diagonal.

4.2.4.5.3 Cut from the sample, three specimens 6" ± 1/8" long.

4.2.4.5.4 Place the template on the specimen and, using the back lighting (shadow) feature of the Profile Projector, obtain a photograph at 100X magnification. A total of nine photographs shall be obtained from three locations on the three specimens.

4.2.4.5.5 Measure the spacing shown on the photographs on a line across the midline of the photograph perpendicular to the filament direction.

4.2.4.5.6 The nine photographs will yield data on approximately 75 fiber spacings for comparison against requirements stated in paragraph 3.4.2.

4.2.4.5.7 Photographs shown in Figure 1 have been included to help interpretation.

4.2.4.5.8 Specimen on Photo A, Figure 1, meets the specification providing the one narrow space is measured at its widest point. This deviation from paragraph 4.2.4.5.5, is acceptable in the case of a highly variable spacing because this variation is felt to be due to light refraction resulting from an uneven resin surface.

4.2.4.5.9 Specimen on Photo B, Figure 1, shows three fibers touching the full length of the photo. In this specimen there are two spaces below tolerance. If this were from a specimen of nine photos, the 2% less than .0002 inch allowable would be exceeded and the material rejected.

4.2.4.5.10 Report the results of observations made on three specimens.

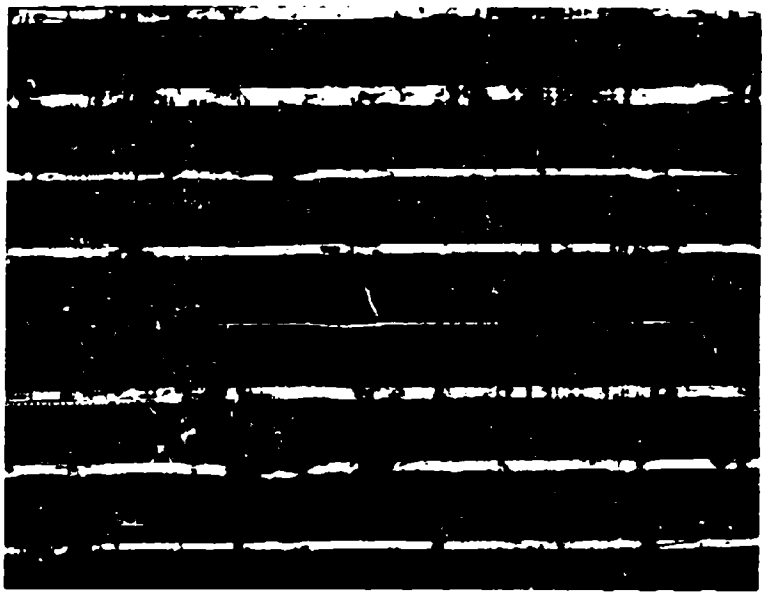

PHOTO A (100X)

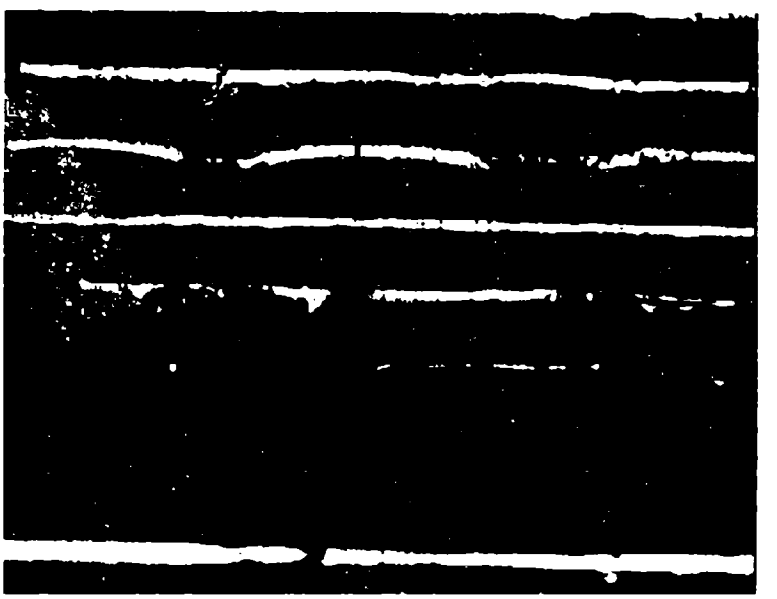

PHOTO B (100X)

FIGURE 1. SAMPLE PHOTOGRAPHS OF FIBER SPACING

4.2.5 Methods of Test for Cured Material - The methods of test for cured material shall be as follows:

4.2.5.1 Flexural Strength (Ultimate) and Flexural Modulus - Minimum Ultimate Flexural Strength and Modulus shall be determined in accordance with ASTM D 790, except that the test specimen shall be a unidirectional beam 3 inches long minimum, 0.250 ± .050 inches wide and 0.080 ± .010 inches thick. Three specimens from one sample taken from each lot shall be tested and the flexural strength and modulus calculated as the arithmetic mean of the three readings.

4.2.5.2 Tensile Strength (Ultimate) and Tensile Modulus - Minimum Ultimate Tensile Strength and Modulus shall be determined in accordance with ASTM D ** Proposed, "Method of Test for Tensile Properties of Highiy Oriented Reinforced Plastics". Three specimens from one sample taken from each lot shall be tested and the tensile strength calculated as tha arithmetic mean of the three readings.

4.2.5.3 Horizontal Shear Strength - Horizontal shear strength shall be determined in accordance with ASTM D ** Proposed, "Method of Test for Apparent Horizontal Shear Strength of Flat Laminates". Three specimens from one sample taken from each lot shall be tested and the shear strength calculated as the arithmetic mean of the three readings.

4.2.5.4 Resin Content-Leco Process - Resin content by the Leco process shall be determined in accordance with ASTM D ** Proposed, "Method of Test for the Determination of Organic Resin Content in a Boron Filament Reinforced Plastic Composite" or a method of equivalent accuracy.

4.2.5.4.1 Calculate resin content percent, as the arithmetic mean of the values obtained from three specimens.

4.2.6 Specimen Conditioning - The test specimens shall be conditioned and tested in an enclosed space maintained at room temperature in the range of 20° to 30°C (68° to 85°F) in accordance with ASTM D 618 Definition C.

5. PREPARATION FOR DELIVERY

5.1 Packaging

5.1.1 Materials

5.1.1.1 Non-adherent separator band.

5.1.1.2 Aluminum or cardboard 7 3/4 ± 1/16 inches inside diameter core.

5.1.1.3 Grade "A" silica gel or equivalent desiccant.

5.1.1.4 Identification tag per paragraph 5.6.

5.1.1.5 Moistureproof plastic bag.

5.1.2 Procedure

5.1.2.1 Tapes up to 1/2 inch width - Wind tape on core wrapped with a 10 inch long separator band section, starting 1/2 inch away from one edge of core and continuing spiral windings 1/2 inch apart up to 1/2 inch minimum from other edge of core. Subsequent wrappings shall be made without cutting the tape and inserting 10 inch long separator band sections between each wrapping.

5.1.2.2 Tapes over 1/2 inch width - Lay continuous length tape on separator band. Tape shall be centered on separator band. Distance from either edge of tape to the corresponding edge of the separator band shall be equal to within ± 1/32 inch. Wind separator band with tape around core under tension. Tension shall be reduced on outer layers to prevent inner layers from buckling. Distance of either edge of separator band to the corresponding edge of core shall not vary more than one percent of the separator band width.

5.1.2.3 Variations in width of tape and separator band shall be ascertained with a noncontact measurement apparatus and reported to the nearest 0.001 inch. The width of tape and separator band shall be within ± 1% of that specified.

5.1.2.4 Place identification tag and desiccant on inside surface of core. Seal each individual roll of tape inside a moistureproof plastic bag.

5.2 Packing - Packaged materials shall be packed in clean dry containers so constructed as to insure acceptance by common or other carrier for safe transportation to the place of delivery specified by the procuring activity. Cartons shall be so constructed and insulated that solid carbon dioxide may be packed in sufficient quantities to maintain a material temperature not to exceed -18°C (0°F), for up to 48 hours.

5.3 Preservation - Packaged materials shall, immediately upon completion of packaging as described in paragraph 5.1, be refrigerated to -18°C (0°F) or lower, at which temperature they shall be maintained until packed as described in paragraph 5.2. As soon as possible after packing, solid carbon dioxide shall be added to the container, so that the material is kept at -18°C (0°F), or lower.

5.4 Shipping - Cartons containing "B" Stage Boron material shall be shipped in such a manner that the temperature of -18°C (0°F) maximum is maintained. There shall be solid carbon dioxide present upon receipt at the procuring activity.

5.5 Storage - Upon delivery of the cartons containing the material to the procuring activity receiving docks, the material shall immediately be placed in storage below -18°C (0°F). A written record shall be maintained for each roll of material listing each time that a roll is removed from -18°C (0°F) storage and time when it is returned. When other storing conditions are demanded, these shall be as agreed upon between the supplier and the procuring activity.

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5.6 Marking - Each package shall be legibly and durably marked by means of a tag, securely attached, in such a manner that it remains in place until all material of the roll is completely used. The identification tag shall be placed in the package and the intermediate package. Information on the tags shall include, but not be limited to the following:

a. Title, number and change letter of this specification.

b. Type, per Table I.

c. Date of impregnation.

d. Width of the material.

e. Linear feet in roll.

f. Supplier's lot number.

g. Manufacturer's trade name.

h. Resin system.

i. CAUTION: Ship and store below -18°C (0°F).

j. Storage life expiration date.

k. Purchase order number.

5.7 Shipping containers shall be marked in accordance with MIL-STD-129. Marking shall include, but not be limited to, the following information:

a. Title, number and change letter of this specification.

b. Type, per Table I.

c. Manufacturer's and supplier's name.

d. Material trade name.

e. Supplier's lot number.

f. Nominal width and length per roll.

g. Number of rolls in packaging container.

h. Shipping and storage requirements.

i. Fragile.

j. Purchase order number.

6. NOTE

6.1 Intended Use - The material covered by this specification is for use in aircraft structures and aerospace applications.

6.2 Ordering Data - Procurement documents for the material shall specify the following:

a. Title, number and change letter of this document.

b. Type, per Table 1.

c. Packaging and packing required and container size.

d. Width and length required.

e. Resin system.

f. Refrigerated Transportation.

PREPREG QUALITY CONTROL RECEIVING INSPECTION REPORT

MATERIAL Boron/5505 1/4" Tape LOT NO. 219

DMS 1919 VENDOR Marsco S/O 162J301 A 162J301 P/O 7CJ-366289

DATE OF MFR. 5/18/67 DATE RECEIVED 5/23/67 QTY. RECEIVED 8.2 lbs (15,925 yds) NO. OF UNITS 4

FOLLOWING IS A DETAILED REPORT OF THE RESULTS OF TESTING

TEST	TEST METHOD	REQUIREMENTS	AVE. VALUES	NO. TESTS (RANGE)	VENDOR RESULTS
A) UNCURED MATERIAL 1) RESIN CONTENT (% by wt.)	DMS 1919A	32±3	29.4	2 (29.1-29.7)	Ave 33.0 Range 32.1-33.9
2) VOLATILE CONTENT (% by wt.)	DMS 1919A	2 max.	0.78	2 (.46-1.08)	Ave 0.34 Range
3) RESIN FLOW (% by wt.)				( )	17.9
4) FILAMENT COUNT AND SPACING	Visual	2511		( )	
5)				( )	
6)				( )	
B) CURED MATERIAL 1) FLEXURAL STRENGTH (PSI)	DMS 1919A	225,000	284,000	1 ( )	231,900
2) FLEXURAL MODULUS (PSI)	DMS 1919A	26×10^6	$28.8 (35.0)^*$	1 ( )	29.4×10^6
3) HORIZONTAL SHEAR STRENGTH (PSI)	DMS 1919A	8500	7,700**	( )	9,400
4) RESIN CONTENT (% by wt.)	DMS 1919A	25±3	Not tested	( )	
5) VOID CONTENT (% by vol.)	DMS 1919A	2 max.	Not tested	( )	
6)				( )	

REMARKS

*Estimated value for 32:1 span ratio
**7:1 span ratio used. Considered acceptable

☒ MEETS SPEC REQUIREMENT
☐ DOES NOT MEET SPEC REQ.
☒ MEETS P.O. REQ.
☐ DOES NOT MEET P.O. REQ.

COGNIZANT ENGINEER

DATE

PREPREG QUALITY CONTROL RECEIVING INSPECTION REPORT

MATERIAL Boron/5505 3" Tape LOT NO. 220

DMS 1919 VENDOR Marsco S/O 162J301 P/O 7CJ-366289

DATE OF MFR. 5/19/67 DATE RECEIVED 5/26/67 QTY. RECEIVED 9.6 lbs (660 ft.) NO. OF UNITS 5

FOLLOWING IS A DETAILED REPORT OF THE RESULTS OF TESTING

TEST	TEST METHOD	REQUIREMENTS	AVE. VALUES	NO. TESTS (RANGE)	VENDOR RESULTS
A) UNCURED MATERIAL 1) RESIN CONTENT (% by wt.)	DMS 1919A	32±3	30.8	4 (29.6-32.7)	Ave 32.9 Range 32.7-33.1
2) VOLATILE CONTENT (% by wt.)	DMS 1919A	2 max.	1.00	3 (0.6-1.2)	0.34
3) RESIN FLOW (% by wt.)				( )	17.9
4) FILAMENT COUNT AND SPACING	DMS 1919A	2162B	spacing fair to poor **	( )	
5)				( )	
6)				( )	
B) CURED MATERIAL 1) FLEXURAL STRENGTH (PSI)	DMS 1919A	225,000	269,600	1 ( )	238,100
2) FLEXURAL MODULUS (PSI)	DMS 1919A	26×10^6	34.9×10^6	1 ( )	29.4×10^6
3) HORIZONTAL SHEAR STRENGTH (PSI)	DMS 1919A	8500	not tested	( )	9,400
4) RESIN CONTENT (% by wt.)	DMS 1919A	25±3	not tested	( )	
5) VOID CONTENT (% by vol.)	DMS 1919A	2 max.	not tested	( )	
6)				( )	

REMARKS

*Span ratio 32:1
**Acceptable for hand lay-up

☒ MEETS SPEC REQUIREMENT
☐ DOES NOT MEET SPEC REQ.
☒ MEETS P.O. REQ.
☐ DOES NOT MEET P.O. REQ.

COGNIZANT ENGINEER

DATE

PREPREG QUALITY CONTROL RECEIVING INSPECTION REPORT

MATERIAL Boron/5505 5" Tape LOT NO. 240

CMS 1919 VENDOR Hercules S/O 16211301 P/O PC1-366289

DATE OF MFR. 9/1/67 DATE RECEIVED 9/15/67 QTY. RECEIVED 23.5 lbs (1592 ft) NO. OF UNITS 11

FOLLOWING IS A DETAILED REPORT OF THE RESULTS OF TESTING

TEST	TEST METHOD	REQUIREMENTS	AVE. VALUES	NO. TESTS (RANGE)	VENDOR RESULTS
A) UNCURED MATERIAL 1) RESIN CONTENT (% by wt.)	CMS 1919A	32±3		( )	32.7
2) VOLATILE CONTENT (% by wt.)	CMS 1919A	2 max.		( )	0.24
3) RESIN FLOW (% by wt.)				( )	15.2
4) FILAMENT COUNT AND SPACING	CMS 1919A	21648		( )	
5)				( )	
6)				( )	
B) CURED MATERIAL 1) FLEXURAL STRENGTH (PSI)	CMS 1919A	225,000		( )	248,500
2) FLEXURAL MODULUS (PSI)	CMS 1919A	26 x 10^6		( )	26.9 x 10^6
3) HORIZONTAL SHEAR STRENGTH (PSI)	CMS 1919A	8,500		( )	10,230
4) RESIN CONTENT (% by wt.)	CMS 1919A	25±3		( )	
5) VOID CONTENT (% by vol.)	CMS 1919A	2 max.		( )	
6)				( )	

REMARKS

This entire lot returned for poor workmanship - primarily excess tack

☐ MEETS SPEC REQUIREMENT
☒ DOES NOT MEET SPEC REQ.
☐ MEETS P.O. REQ.
☒ DOES NOT MEET P.O. REQ.

COGNIZANT ENGINEER

DATE

PREPREG QUALITY CONTROL RECEIVING INSPECTION REPORT

MATERIAL Boron/5505 5" Tape LOT NO. 249

CMS 1919 VENDOR Hercules S/O 16211301, 16211401, 84399715 P/O PC1-366842, PC1-366844, PC1-366789

DATE OF MFR. 9-28 9-29 / 9/8 & 9/26/67 DATE RECEIVED 9/29, 10/4, 10/16/67 QTY. RECEIVED 3460 ft (48, 78) NO. OF UNITS 28

FOLLOWING IS A DETAILED REPORT OF THE RESULTS OF TESTING

TEST	TEST METHOD	REQUIREMENTS	AVE. VALUES	NO. TESTS (RANGE)	VENDOR RESULTS
A) UNCURED MATERIAL 1) RESIN CONTENT (% by wt.)	CMS 1919A	32±3	30.4	1 ( )	30.6
2) VOLATILE CONTENT (% by wt.)	CMS 1919A	2 max.	0.91	1 ( )	0.26
3) RESIN FLOW (% by wt.)				( )	19.0
4) FILAMENT COUNT AND SPACING	CMS 1919A	21648	spacing ok	( )	
5)				( )	
6)				( )	
B) CURED MATERIAL 1) FLEXURAL STRENGTH (PSI)	CMS 1919A	225,000	255,800	1 ( )	246,000
2) FLEXURAL MODULUS (PSI)	CMS 1919A	26.0 x 10^6	23.4 (31.2)	1 ( )	26.4 x 10^6
3) HORIZONTAL SHEAR STRENGTH (PSI)	CMS 1919A	8,500	8,000**	1 ( )	10,070
4) RESIN CONTENT (% by wt.)	CMS 1919A	25±3	20.8	1 ( )	
5) VOID CONTENT (% by vol.)	CMS 1919A	2 max.	4.9	1 ( )	
6)				( )	

REMARKS

*Estimated value for 32:1 span ratio
**7:1 span ratio used

☐ MEETS SPEC REQUIREMENT
☒ DOES NOT MEET SPEC REQ.
☒ MEETS P.O. REQ.
☐ DOES NOT MEET P.O. REQ.

COGNIZANT ENGINEER

DATE

PREPREG QUALITY CONTROL RECEIVING INSPECTION REPORT

MATERIAL Boron/5505 3" Tape LOT NO. 262
DMS 1919 VENDOR Narmco S/O 16211301 P/O 7C1-366289
DATE OF MFR. 11/14/67 DATE RECEIVED 12/1/67 QTY. RECEIVED 29.9 lbs(2,733 ft) NO. OF UNITS 11

FOLLOWING IS A DETAILED REPORT OF THE RESULTS OF TESTING

TEST	TEST METHOD	REQUIREMENTS	AVE. VALUES	NO. TESTS (RANGE)	VENDOR RESULTS
A) UNCURED MATERIAL 1) RESIN CONTENT (% by wt.)	DMS 1919A	32±3	32.4	10 (30.0-36.0)	32.8
2) VOLATILE CONTENT (% by wt.)	DMS 1919A	2 max.	1.22	9 (0.32-1.33)	0.53
3) RESIN FLOW (% by wt.)				( )	11.7
4) FILAMENT COUNT AND SPACING	DMS 1919A	2168	spacing ok - except coil 8	( )	
5)				( )	
6)				( )	
B) CURED MATERIAL 1) FLEXURAL STRENGTH (PSI)	DMS 1919A	225,000	256,400	2 (253,500-259,300)	254,900
2) FLEXURAL MODULUS (PSI)	DMS 1919A	26.0×10^6	24.8 (32.2)*	2 (31.5-33.0)	29.0×10^6
3) HORIZONTAL SHEAR STRENGTH (PSI)	DMS 1919A	8,500	8,440**	2 (8,200**-8,680**)	9,670
4) RESIN CONTENT (% by wt.)	DMS 1919A	25±3	23.3	2 (22.1-24.5)	
5) VOID CONTENT (% by vol.)	DMS 1919A	2 max.	5.0	2 (3.1-6.9)	
6)				( )	

REMARKS

*Estimated value for 32.1 span ratio
**7:1 span ratio used

☐ MEETS SPEC REQUIREMENT
☒ DOES NOT MEET SPEC REQ.
☒ MEETS P.O. REQ.
☐ DOES NOT MEET P.O. REQ.

H. M. Taeblner
COGNIZANT ENGINEER
DATE

PREPREG QUALITY CONTROL RECEIVING INSPECTION REPORT

MATERIAL Boron/5505 3" Tape LOT NO. 268
DMS 1919 VENDOR Narmco S/O 16211301 and 16211401 P/O 7C1-472664
DATE OF MFR. 1-18-68 DATE RECEIVED 1-29-68 QTY. RECEIVED 14.2 lbs(998 ft) NO. OF UNITS 4

FOLLOWING IS A DETAILED REPORT OF THE RESULTS OF TESTING

TEST	TEST METHOD	REQUIREMENTS	AVE. VALUES	NO. TESTS (RANGE)	VENDOR RESULTS
A) UNCURED MATERIAL 1) RESIN CONTENT (% by wt.)	DMS 1919A	32±3	29.6	4 (29.0-30.6)	31.0
2) VOLATILE CONTENT (% by wt.)	DMS 1919A	2 max.	1.36	4 (1.17-1.47)	0.24
3) RESIN FLOW (% by wt.)				( )	10.9
4) FILAMENT COUNT AND SPACING	DMS 1919A	216±	spacing ok	( )	
5)				( )	
6)				( )	
B) CURED MATERIAL 1) FLEXURAL STRENGTH (PSI)	DMS 1919A	225,000	247,800	( )	237,100
2) FLEXURAL MODULUS (PSI)	DMS 1919A	26.0×10^6	23.1 (30.8)*	( )	27.5×10^6
3) HORIZONTAL SHEAR STRENGTH (PSI)	DMS 1919A	8,500	7,800**	( )	8,870
4) RESIN CONTENT (% by wt.)	DMS 1919A	25±3	21.58	( )	
5) VOID CONTENT (% by vol.)	DMS 1919A	2 max.	4.53	( )	
6)				( )	

REMARKS

*Estimated value for 32:1 span ratio
**7:1 span ratio used

☐ MEETS SPEC REQUIREMENT
☒ DOES NOT MEET SPEC REQ.
☒ MEETS P.O. REQ.
☐ DOES NOT MEET P.O. REQ.

H. M. Taeblner
COGNIZANT ENGINEER
DATE

PREPREG QUALITY CONTROL RECEIVING INSPECTION REPORT

MATERIAL Boron/5505 3" Tape LOT NO. 278
DMS 1919 VENDOR Narmco S/O 16211301 P/O BCY-637813
DATE OF MFR. 3/20/68 DATE RECEIVED 3/29/68 QTY. RECEIVED 31.2 lbs(2212 ft) NO. OF UNITS 9

FOLLOWING IS A DETAILED REPORT OF THE RESULTS OF TESTING

TEST	TEST METHOD	REQUIREMENTS	AVE. VALUES	NO. TESTS (RANGE)	VENDOR RESULTS
A) UNCURED MATERIAL 1) RESIN CONTENT (% by wt.)	DMS 1919A	32±3	32.5	4 (30.5 / 33.5)	Ave 31.1 Range 30.5-32.1
2) VOLATILE CONTENT (% by wt.)	DMS 1919A	2 max.	0.94	4 (0.60 / 1.37)	0.36
3) RESIN FLOW (% by wt.)				( )	13.3
4) FILAMENT COUNT AND SPACING	DMS 1919A	216±8	spacing ok	( )	
5)				( )	
6)				( )	
B) CURED MATERIAL 1) FLEXURAL STRENGTH (PSI)	DMS 1919A	225,000	259,500	1 ( )	260,300
2) FLEXURAL MODULUS (PSI)	DMS 1919A	26.0×10^6	29.5×10^6	1 ( )	28.3×10^6
3) HORIZONTAL SHEAR STRENGTH (PSI)	DMS 1919A	8500	9,370	1 ( )	9,450
4) RESIN CONTENT (% by wt.)	DMS 1919A	25±3	23.0	1 ( )	
5) VOID CONTENT (% by vol.)	DMS 1919A	2 max.	2.67	1 ( )	
6)				( )	

REMARKS
*Span Ratio 32:1

[X] MEETS SPEC REQUIREMENT
[ ] DOES NOT MEET SPEC REQ.
[X] MEETS P.O. REQ.
[ ] DOES NOT MEET P.O. REQ.

N M Tadlock
COGNIZANT ENGINEER
DATE

PREPREG QUALITY CONTROL RECEIVING INSPECTION REPORT

MATERIAL Boron/5505 3" Tape LOT NO. 262
DMS 1919 VENDOR Narmco S/O 16211391 and 16211401 P/O BCY-637812
DATE OF MFR. 4/15/68 DATE RECEIVED 4/22/68 QTY. RECEIVED 26.0 lbs(1394 ft) NO. OF UNITS 7

FOLLOWING IS A DETAILED REPORT OF THE RESULTS OF TESTING

TEST	TEST METHOD	REQUIREMENTS	AVE. VALUES	NO. TESTS (RANGE)	VENDOR RESULTS
A) UNCURED MATERIAL 1) RESIN CONTENT (% by wt.)	DMS 1919A	32±3	32.2	7 (31.1 / 33.5)	Ave 31.3 Range 30.8-32.4
2) VOLATILE CONTENT (% by wt.)	DMS 1919A	2 max.	1.44	7 (1.06 / 1.71)	0.25
3) RESIN FLOW (% by wt.)				( )	12.2
4) FILAMENT COUNT AND SPACING	DMS 1919A	216±8	spacing ok	( )	
5)				( )	
6)				( )	
B) CURED MATERIAL 1) FLEXURAL STRENGTH (PSI)	DMS 1919A	225,000	280,300	1 ( )	274,400
2) FLEXURAL MODULUS (PSI)	DMS 1919A	26.0×10^6	31.1×10^6*	1 ( )	30.2×10^6
3) HORIZONTAL SHEAR STRENGTH (PSI)	DMS 1919A	8,500	9,050	1 ( )	9,870
4) RESIN CONTENT (% by wt.)	DMS 1919A	25±3	23.6	1 ( )	
5) VOID CONTENT (% by vol.)	DMS 1919A	2 max.	2.48	1 ( )	
5)				( )	

REMARKS *Span ratio 32:1

[X] MEETS SPEC REQUIREMENT
[ ] DOES NOT MEET SPEC REQ.
[X] MEETS P.O. REQ.
[ ] DOES NOT MEET P.O. REQ.

N M Tadlock
COGNIZANT ENGINEER
DATE

PREPREG QUALITY CONTROL RECEIVING INSPECTION REPORT

MATERIAL Boron/5505 3" Tape LOT NO. 285
DMS 1919 VENDOR Hamaco S/O 16211301 and 16211401 P/O BCY-687095
DATE OF MFR. 5/15, 5/16 & 5/17/68 DATE RECEIVED 5/27/68 QTY. RECEIVED 42.0 lbs (2728 ft) NO. OF UNITS 11

FOLLOWING IS A DETAILED REPORT OF THE RESULTS OF TESTING

TEST	TEST METHOD	REQUIREMENTS	AVE. VALUES	NO. TESTS (RANGE)	VENDOR RESULTS
A) UNCURED MATERIAL 1) RESIN CONTENT (% by wt.)	DMS 1919A	32±3	33.5	3 (33.2 - 33.7)	Ave. 31.97 Range 30.8-33.
2) VOLATILE CONTENT (% by wt.)	DMS 1919A	2 max.	0.95	3 (0.55 - 1.25)	0.49
3) RESIN FLOW (% by wt.)				( )	17.9
4) FILAMENT COUNT AND SPACING	DMS 1919A	216±8	spacing ok	( )	
5)				( )	
6)				( )	
B) CURED MATERIAL 1) FLEXURAL STRENGTH (PSI)	DMS 1919A	225,000	257,600	1 ( )	244,000
2) FLEXURAL MODULUS (PSI)	DMS 1919A	26 x 10^6	28.8 x 10^6*	1 ( )	27.5 x 10^6
3) HORIZONTAL SHEAR STRENGTH (PSI)	DMS 1919A	8,500	9,520	1 ( )	9,200
4) RESIN CONTENT (% by wt.)	DMS 1919A	25±3	27.6	1 ( )	
5) VOID CONTENT (% by vol.)	DMS 1919A	2 max.	1.25	1 ( )	
6)				( )	

REMARKS
*Span ratio 32:1

☒ MEETS SPEC REQUIREMENT
☐ DOES NOT MEET SPEC REQ.
☒ MEETS P.O. REQ.
☐ DOES NOT MEET P.O. REQ.

H. M. Tasklosen
COGNIZANT ENGINEER
DATE

PREPREG QUALITY CONTROL RECEIVING INSPECTION REPORT

MATERIAL Boron/5505 3" Tape LOT NO. 297**
DMS 1919 VENDOR Hamaco** S/O 16211301 P/O None**
DATE OF MFR. 9/5/68 DATE RECEIVED 11/27/68 QTY. RECEIVED 8.0 lbs (622 ft) NO. OF UNITS 2

FOLLOWING IS A DETAILED REPORT OF THE RESULTS OF TESTING

TEST	TEST METHOD	REQUIREMENTS	AVE. VALUES	NO. TESTS (RANGE)	VENDOR RESULTS **
A) UNCURED MATERIAL 1) RESIN CONTENT (% by wt.)	DMS 1919A	32±3	33.5	2 (32.6 - 34.4)	not received
2) VOLATILE CONTENT (% by wt.)	DMS 1919A	2 max.	0.41	2 (0.40 - 0.53)	not received
3) RESIN FLOW (% by wt.)				( )	not received
4) FILAMENT COUNT AND SPACING	DMS 1919A	216±8	spacing ok	( )	
5)				( )	
6)				( )	
B) CURED MATERIAL 1) FLEXURAL STRENGTH (PSI)	DMS 1919A	225,000	297,900	2 (290,000 - 305,800)	247,000
2) FLEXURAL MODULUS (PSI)	DMS 1919A	26 x 10^6	33.8 x 10^6	2 (32.6x10^6 - 34.9x10^6)	32.5 x 10^6
3) HORIZONTAL SHEAR STRENGTH (PSI)	DMS 1919A	8,500	8,885	2 (7,780 - 9,990)	10,200
4) RESIN CONTENT (% by wt.)	DMS 1919A	25±3	20.6	2 (18.44 - 22.67)	
5) VOID CONTENT (% by vol.)	DMS 1919A	2 max.	6.82	2 (3.71 - 9.94)	
6)				( )	

REMARKS
**Sent from General Dynamics by AFFDL authorization

☒ MEETS SPEC REQUIREMENT
☐ DOES NOT MEET SPEC REQ.
☐ MEETS P.O. REQ.
☐ DOES NOT MEET P.O. REQ.

H. M. Tasklosen
COGNIZANT ENGINEER
DATE

PREPREG QUALITY CONTROL RECEIVING INSPECTION REPORT

MATERIAL S994-ES901/5505 (Glass) LOT NO. F2236
DMS VENDOR U. S. Polymeric S/O 16211301 P/O 701-472583
DATE OF MFR. 12/4/67 DATE RECEIVED 12/9/67 QTY. RECEIVED 49.3 lbs NO. OF UNITS 12

FOLLOWING IS A DETAILED REPORT OF THE RESULTS OF TESTING

TEST	TEST METHOD	REQUIREMENTS	AVE. VALUES	NO. TESTS (RANGE)	VENDOR RESULTS
A) UNCURED MATERIAL 1) RESIN CONTENT (% by wt.) ORC	45°@1050°F	27±3	28.8	5 (24.* (31.0)	Ave 27.7 Range 24.0* 31.6
2) VOLATILE CONTENT (% by wt.) CAO	15'@300°F	3 max.	0.42	5 (0.37 0.48	Ave 0.73 Range 0.6-0.9
3) RESIN FLOW (% by wt.)		none		( )	Ave 14.8 Range 10.6-19.2
4) FILAMENT COUNT AND SPACING		not applicable		( )	
5)				( )	
6)				( )	
B) CURED MATERIAL 1) FLEXURAL STRENGTH (PSI)	DMS 1919A	not required	206,500	1 ( )	
2) FLEXURAL MODULUS (PSI)	DMS 1919A	not required	7.1 x 10^6	1 ( )	
3) HORIZONTAL SHEAR STRENGTH (PSI)	DMS 1919A	not required	9,180	1 ( )	
4) RESIN CONTENT (% by wt.)	45°@1050°F	not required	24.6	1 ( )	
5) VOID CONTENT (% by vol.)	ASTMD2734	not required	0.72	1 ( )	
6)				( )	

REMARKS
*Results low due to no "end" sample

☐ MEETS SPEC REQUIREMENT
☐ DOES NOT MEET SPEC REQ.
☒ MEETS P.O. REQ.
☐ DOES NOT MEET P.O. REQ.
H. M. Taeltner
COGNIZANT ENGINEER
DATE

PREPREG QUALITY CONTROL RECEIVING INSPECTION REPORT

MATERIAL S901/5505 (Glass) LOT NO. F2234
DMS VENDOR U.S. Polymeric S/O 16711301 P/O ACY-657643
DATE OF MFR. 3-6-68 DATE RECEIVED 3-9-68 QTY. RECEIVED 31.1 lbs NO. OF UNITS 7

FOLLOWING IS A DETAILED REPORT OF THE RESULTS OF TESTING

TEST	TEST METHOD	REQUIREMENTS	AVE. VALUES	NO. TESTS (RANGE)	VENDOR RESULTS
A) UNCURED MATERIAL 1) RESIN CONTENT (% by wt.) ORC	45°@1050°F	27±3	29.6	7 (27.0- (31.7)	Ave 27.09 Range 25.0-30.1
2) VOLATILE CONTENT (% by wt.) CAO	15'@300°F	3 max	0.48	7 (0.36 0.68	Ave 0.8 Range 0.5-1.1
3) RESIN FLOW (% by wt.)		none		( )	Ave 11.1 Range 9.2-13.3
4) FILAMENT COUNT AND SPACING		not applicable		( )	
5)				( )	
6)				( )	
B) CURED MATERIAL 1) FLEXURAL STRENGTH (PSI)	DMS 1919A	not required	259,200	1 ( )	
2) FLEXURAL MODULUS (PSI)	DMS 1919A	not required	9.1 x 10^6	1 ( )	
3) HORIZONTAL SHEAR STRENGTH (PSI)	DMS 1919A	not required	9,130	1 ( )	
4) RESIN CONTENT (% by wt.)	45°@1050°F	not required	19.3	1 ( )	
5) VOID CONTENT (% by vol.)	ASTMD2734	not required	0.30	1 ( )	
6)				( )	

REMARKS

☐ MEETS SPEC REQUIREMENT
☐ DOES NOT MEET SPEC REQ.
☒ MEETS P.O. REQ.
☐ DOES NOT MEET P.O. REQ.
H. M. Taeltner
COGNIZANT ENGINEER
DATE

PREPREG QUALITY CONTROL RECEIVING INSPECTION REPORT

MATERIAL 5994/5505 (Glass) LOT NO. F2256
DMS VENDOR U. S. Polymeric S/O 16211301 P/O BCY-637823
DATE OF MFR. 4/4/68 DATE RECEIVED 4/12/68 QTY. RECEIVED 52.0 lbs NO. OF UNITS 7

FOLLOWING IS A DETAILED REPORT OF THE RESULTS OF TESTING

TEST	TEST METHOD	REQUIREMENTS	AVE. VALUES	NO. TESTS (RANGE)	VENDOR RESULTS
A) UNCURED MATERIAL 1) RESIN CONTENT (% by wt.) DRC	45'@1050°F	27±3	28.4	3 (27.4-29.1)	Ave 28.5 Range 27.6-29.1
2) VOLATILE CONTENT (% by wt.) CAO	15'@300°F	3 max	0.24	3 (0.13-0.38)	Ave 1.0 Range 0.8-1.1
3) RESIN FLOW (% by wt.)		none		( )	
4) FILAMENT COUNT AND SPACING		not applicable		( )	
5)				( )	
6)				( )	
B) CURED MATERIAL 1) FLEXURAL STRENGTH (PSI)	DMS 1919A	not required	267,000	1 ( )	
2) FLEXURAL MODULUS (PSI)	DMS 1919A	not required	8.7×10^6	1 ( )	
3) HORIZONTAL SHEAR STRENGTH (PSI)	DMS 1919A	not required	7,840	1 ( )	
4) RESIN CONTENT (% by wt.)	45'@1050°F	not required	18.9	1 ( )	
5) VOID CONTENT (% by vol.)	ASTMD2734	not required	1.4	1 ( )	
6)				( )	

REMARKS

☐ MEETS SPEC REQUIREMENT
☐ DOES NOT MEET SPEC REQ.
☒ MEETS P.O. REQ.
☐ DOES NOT MEET P.O. REQ.
H. M. Taellner
COGNIZANT ENGINEER
DATE

PREPREG QUALITY CONTROL RECEIVING INSPECTION REPORT

MATERIAL 5901/5505 (Glass) LOT NO. E2270
DMS VENDOR U.S. Polymeric S/O 16211301 P/O BCY-687605
DATE OF MFR. 6/20/68 DATE RECEIVED 6/24/68 QTY. RECEIVED 322 lbs NO. OF UNITS 4

FOLLOWING IS A DETAILED REPORT OF THE RESULTS OF TESTING

TEST	TEST METHOD	REQUIREMENTS	AVE. VALUES	NO. TESTS (RANGE)	VENDOR RESULTS
A) UNCURED MATERIAL 1) RESIN CONTENT (% by wt.) DRC	45'@1050°F	27±3		( )	Ave 24.0 Range 21.8-30.7
2) VOLATILE CONTENT (% by wt.) CAO	15'@300°F	3 max		( )	Ave 0.76 Range 0.7-0.9
3) RESIN FLOW (% by wt.)		none		( )	
4) FILAMENT COUNT AND SPACING		not applicable		( )	
5)				( )	
6)				( )	
B) CURED MATERIAL 1) FLEXURAL STRENGTH (PSI)	DMS 1919A	not required	249,800	( )	
2) FLEXURAL MODULUS (PSI)	DMS 1919A	not required	9.1×10^6	( )	
3) HORIZONTAL SHEAR STRENGTH (PSI)	DMS 1919A	not required	9,500	( )	
4) RESIN CONTENT (% by wt.)	DMS 1919A	not required	20.2	( )	
5) VOID CONTENT (% by vol.)	ASTMD2734	not required	5.49	( )	
6)				( )	

REMARKS
Narrow bondwidth

☐ MEETS SPEC REQUIREMENT
☐ DOES NOT MEET SPEC REQ.
☒ MEETS P.O. REQ.
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H. M. Taellner
COGNIZANT ENGINEER
DATE

RESIN AND VOID CONTENT DETERMINATIONS

Laminates from the joint specimens were tested for density and resin content to facilitate interpretation of the joint strength tests. Void contests of the reinforced composite panels were calculated using contractor measurements of laminate density and resin content and vendor-supplied information on fiber and resin density. Laminate density was determined using ASTM D792-64T. Void content was determined in accordance with ASTM D2734.

Resin content for the fiber glass laminates was determined using a burnout technique similar to Method 7061, FTMS 406, except that a burnout temperature of 1450°F was used. A vacuum pyrolysis technique was used to determine resin content in the boron laminates. To implement this method for resin determination, a conversion factor relating pyrolysis loss to resin content was determined by correlating test results for S-994 fiber glass/Narmco 5505 composites with those obtained using the burnout method (see Reference 1).

The vacuum pyrolysis method was conducted as follows:

- The equipment was set up as shown in Figure 115.
- A 0.5- to 3.5-gram sample was weighed to within ±0.001 gram and placed in a Vycor test tube.
- A negative pressure of less than 10mm of mercury was drawn in the test tube.
- Full heat of a Fisher or Meeker burner was applied to the sample (2000° to 2400°F). Two burners were used in some cases. The heating was continued until sample weight stabilized. This point was determined to be the point where no vapors were being evolved as indicated by a sensitive manometer (or was assumed to be 60 minutes of heating, whichever occurred first).
- The apparatus was cooled under vacuum to room temperature, and the charred remains of the laminate were carefully removed and weighed to within ±0.001 gram.
- Calculations were performed as follows:

$$\% \text{ Resin Content} = K_1 \left(\frac{W_1 - W_2}{W_1} \right) \times 100$$

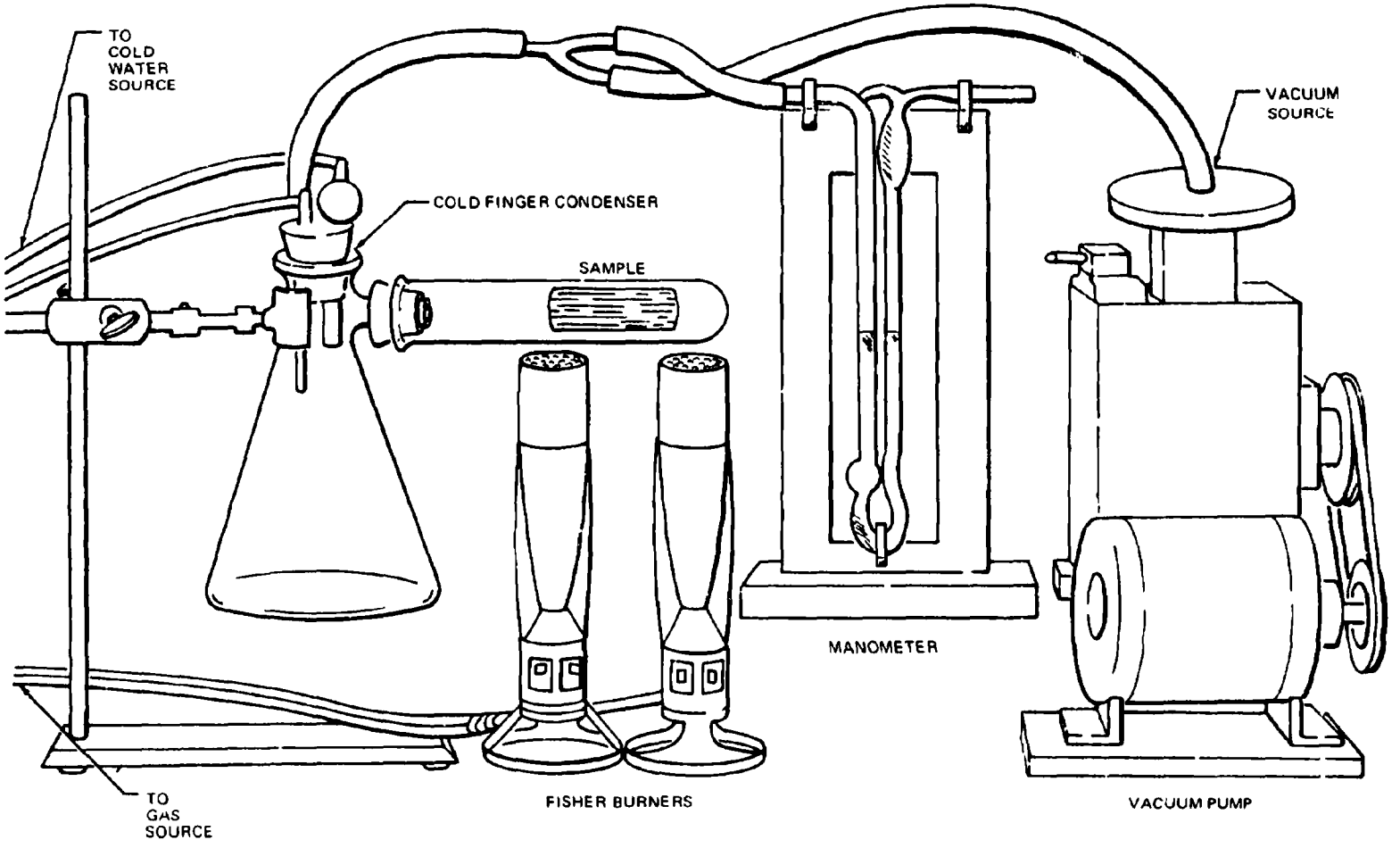

FIGURE 115. SETUP FOR DETERMINATION OF RESIN CONTENT BY VACUUM PYROLYSIS

where

W_1 = Original Sample Weight

W_2 = Pyrolyzed Sample Weight

K_1 = Conversion Factor

The conversion factor, K_1, was determined for Narmco 5505 resin by relating pyrolysis loss to resin content as determined by the burnout method on fiber glass laminates. The conversion factor had the form

$$K_1 = b + m\left(\frac{W_1 - W_2}{W_1}\right)$$

For Narmco 5505 resin, b = 1.0934 and m = 0.1325. These constants were determined by a curve-fitting technique on a plot of K_1 versus $(W_1 - W_2)/W_1$.

Void content was determined using the following definition from ASTM D2734.

$$\% \text{ Void Content} = \left(\frac{\text{Theoretical Density - Actual Density}}{\text{Theoretical Density}}\right)$$

This equation was algebraically rearranged to the following form:

$$\% \text{ Void Content} = Q = \left\{1 - \left[\frac{1}{D_F} - \left(\frac{1}{D_F} - \frac{1}{D_R}\right) Z\right] D_L\right\} \times 100 \qquad (1)$$

where

D_F = Density of the Filament (grams/cc)

D_R = Density of the Resin (grams/cc)

Z = Resin Content Fraction (by weight)

D_L = Density of the Laminate (grams/cc)

With $D_F = 2.62$ and $D_R = 1.246$, the calculation for Boron/5505 reduced to:

$$\text{Volume \% Void Content} = Q = \left[1 - (0.381 + 0.421Z)D_L\right] \times 100$$

With $D_F = 2.48$ and $D_R = 1.246$, the calculation for S-994 Glass/5505 reduced to:

$$\text{Volume \% Void Content, } Q = \left[1 - (0.403 + 0.400Z)D_L\right] \times 100$$

The accuracy of the void content is statistically dependent on the variation of the elements of its calculation in the following manner (see Reference 2).

$$\sigma^2(Q) = \left(\frac{\partial Q}{\partial D_F}\right)^2 \sigma^2(D_F) + \left(\frac{\partial Q}{\partial D_R}\right)^2 \sigma^2(D_R) + \left(\frac{\partial Q}{\partial D_L}\right)^2 \sigma^2(D_L) + \left(\frac{\partial Q}{\partial Z}\right)^2 \sigma^2(Z) \qquad (2)$$

Where $\sigma^2(Q)$, $\sigma^2(D_F)$, $\sigma^2(D_R)$, $\sigma^2(D_L)$ and $\sigma^2(Z)$ represent the statistical variances of the respective quantities.

Employing Equations (1) and (2) and taking the appropriate partial derivatives, the following equation was formulated.

$$\sigma^2(Q) = \left[\frac{(D_L)(1-Z)}{(D_F)^2}\right]^2 \sigma^2(D_F) + \left[\frac{(D_L)(Z)}{(D_R)^2}\right]^2 \sigma^2(D_R) + \left[(Z)\ \frac{1}{D_R} - \frac{1}{D_F} + \frac{1}{D_F}\right]^2 \sigma^2(D_L) + \left[(D_L)\ \frac{1}{D_R} - \frac{1}{D_F}\right]^2 \sigma^2(Z) \qquad (3)$$

To quantify the magnitude of the variance of void content, $\sigma^2(Q)$, certain logical assumptions were made to reduce Equation (3) to a simpler form. The following values were assumed:

D_L = 2.000 grams/cc

Z = 0.250

D_F = 2.620 grams/cc

D_R = 1.246 grams/cc

These assumed values, with calculations per Equation (1), fix the void content for this example at an average value of 0.028 or 2.80 percent.

It was further assumed that fiber density was known within 0.01 grams/cc, and that the statistical variance of laminate densitiy, $\sigma^2(D_L)$, and resin density, $\sigma^2(D_R)$, were equal. From the assumed accuracy of fiber density,

$$3\sigma(D_F) = 0.01$$

$$\sigma^2(D_F) = \left(\frac{0.01}{3}\right)^2 = 1.111 \times 10^{-5}$$

Thus, Equation (3) was written

$$\sigma^2(Q) = \left[\frac{(2)(0.75)}{(2.62)^2}\right]^2 (1.111 \times 10^{-5}) + \left[\frac{(2)(0.25)}{(1.246)^2}\right]^2 \sigma^2(D_L)$$

$$+ \left[(0.25)\left(\frac{1}{1.246} - \frac{1}{2.62}\right) + \frac{1}{2.62}\right]^2 \sigma^2(D_L)$$

$$+ \left[(2)\left(\frac{1}{1.246} - \frac{1}{2.62}\right)\right]^2 \sigma^2(Z)$$

Upon completing the arithmetic, the following expressions were obtained:

$$\sigma^2(Q) = 5.28 \times 10^{-7} + (0.340)\left[\sigma^2(D_2)\right] + (0.708)\left[\sigma^2(Z)\right] \quad (4)$$

$$\sigma(Q) = \sqrt{\sigma^2(Q)} \quad (5)$$

Figure 116 is a plot of equation (C-4) showing the standard deviation of void content, $\sigma^2(Q)$, versus the standard deviation of laminate density, $\sigma^2(D_L)$, for various resin content test accuracies. Figure 116 indicates that variations in measuring a laminate density of 0.003 grams/cc and a resin content of 0.00188 (±3/4 percent), result in a standard deviation for the void content, $\sigma(Q)$, of 0.00243. Therefore, the total variation of three standard deviations (0.0073) can be represented as

% Void Content = 2.80% ± 0.73% or 2.07 to 3.53%

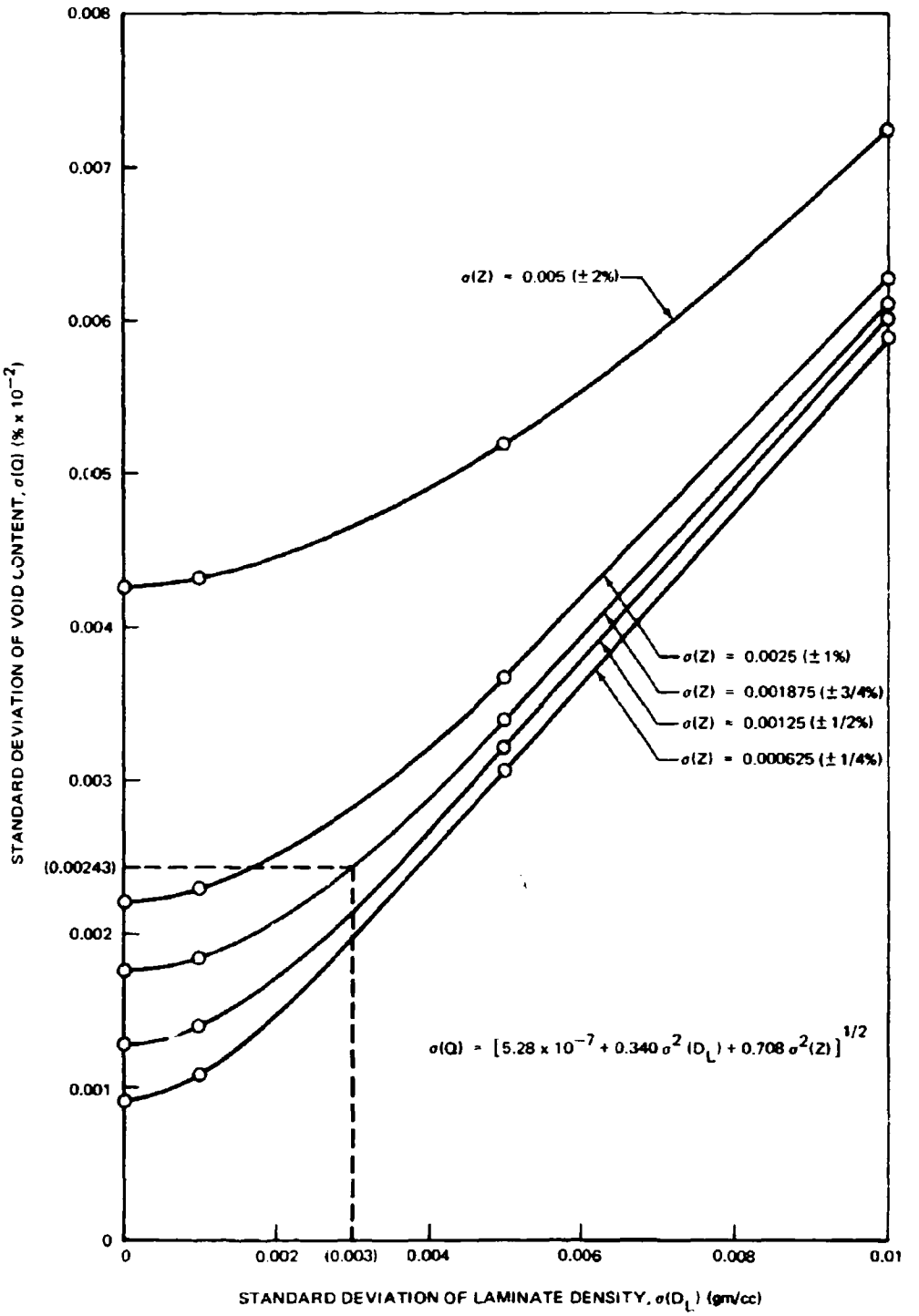

FIGURE 116. ERROR IN VOID CONTENT VERSUS ERROR IN LAMINATE DENSITY FOR VARIOUS RESIN CONTENT ACCURACIES

Obviously the error can be determined for as many different assigned conditions as desired. However, the above assumptions are roughly representative of the current state of the art in void content testing of boron/epoxy composites.

A significant potential error in the assumptions involves the variation of fiber density from laminate to laminate. If this variation was twice that previously assumed (i.e., 0.02 grams/cc rather than 0.01 grams/cc) the variation in void content would be

$$\% \text{ Void Content} = 2.80\% \pm 0.83\% \text{ or } 1.97 \text{ to } 3.63\%$$

Resin content, density, and void content determinations are summarized in Table XXVI. The specimens were identified by the last three digits in the engineering drawing number, the joint configuration dash number, and the individual specimen identification (either a one-digit number or a letter). Reasonable accuracy in density determinations depends on proper specimens (e.g., no fractured areas, maximum size, etc) and a liquid that wets the surface when the specimen is immersed. Consequently the data in Table XXVI where "break areas" were sampled are less reliable than the remainder of the data. The results tend toward low density and high void content in those specimens.

TABLE XXVI
RESIN CONTENT, DENSITY, AND VOID CONTENT OF JOINT SPECIMENS

Property Specimen No.	Resin Content (% by wt.)		(% by vol.)	Density		Void Content (% by volume)		Comments
818.1 -1	29.56			1.9416		1.86		
-2	29.41			1.9600		1.06		
Ave		29.49	46.17		1.9508		1.46	Boron
818-501 -1	26.20			1.9607		0.44		
-2	25.48			1.9562		1.23		
Ave		25.84	40.62		1.9583		0.84	Glass
818-509 -1	29.42			1.9671		0.69		
-2	28.97			1.9584		1.50		
Ave		29.20	46.00		1.9628		1.10	Boron
827.1.4 -1	24.80			2.0210		1.90		Break Area
-2	25.36			2.0201		1.46		Break Area
-3	25.93			2.0077		1.59		
Ave		25.36	41.04		2.0163		1.65	Boron
827-501.1 -1	23.73			2.0450		1.65		Break Area
-2	24.15			2.0202		2.49		Break Area
-3	26.18			1.9936		2.07		
Ave		24.69	40.02		2.0196		2.07	Boron
827.505.1 -3	25.54			2.0148		1.58		
-4	25.29			2.0425		0.43		
-5	24.43			2.0203		2.25		
Ave		25.09	40.79		2.0259		1.42	Boron
827.507.2 -1	25.95			1.9744		3.21		Break Area
-2	24.98			2.0015		2.69		Break Area
-3	25.15			1.9986		2.70		
Ave		25.36	40.53		1.9915		2.87	Boron
827-511-5 -1	26.87			1.9449		0.72		Break Area
-2	27.83			1.9285		0.82		Break Area
-3	26.53			1.9487		0.79		
Ave		27.08	42.18		1.9407		0.78	Glass
827.513.1 -1	26.26			1.9454		1.16		Break Area
-2	26.24			1.9579		0.55		Break Area
-3	26.31			1.9474		1.02		
Ave		26.27	41.12		1.9502		1.12	Glass
827.517.2 -1	26.13			1.9347		1.81		
-2	25.89			1.9547		0.98		Break Area
-3	25.90			1.9729		0.06		
Ave		25.97	40.73		1.9541		0.95	Glass
827.519.3 -1	27.38			1.9278		1.20		Break Area
-2	27.34			1.9393		0.64		Break Area
-3	27.51			1.9187		1.56		
Ave		27.41	42.43		1.9286		1.13	Glass
827.523.2 -1	27.36			1.9844		1.54		Break Area
-2	27.75			1.9887		1.00		
-3	27.65			1.9825		1.23		
Ave		27.65	44.05		1.9852		1.26	Boron
827-527.3 -1	27.32			1.9549		3.03		Break Area
-2	27.62			1.9816		1.46		Break Area
-3	27.77			1.9465		3.08		
Ave		27.57	43.39		1.9610		2.52	Boron
827.529.2 -1	26.83			1.9549		3.03		
-2	26.99			2.0040		1.14		
-3	26.34			2.0131		1.25		
Ave		26.72	42.68		1.9903		1.81	Boron
827.535.4 -1	26.56			1.9613		0.13		Break Area
-2	25.61			1.9672		0.57		Break Area
-3	20.48			2.0455		0.81		
Ave		24.22	38.71		1.9913		0.50	Glass
827.539.3 -1	20.86			2.0527		0.15		Break Area
-2	21.43			2.0199		1.29		Break Area
-3	26.52			1.9432		1.08		
Ave		22.94	36.92		2.0053		0.84	Glass
826.1.2 -1	25.82			1.9962		2.25		Break Area
-2	25.95			1.9978		2.06		Break Area
-3	25.84			2.0013		1.98		
Ave		25.87	41.49		1.9984		2.10	Boron
828.501.5 -1	27.44			1.9710		2.13		Break Area
-2	26.32			1.9962		1.80		Break Area
-3	27.99			1.9498		2.74		
Ave		27.25	43.13		1.9723		2.22	Boron
828.507.5 -1	27.24			1.9350		4.09		Break Area
-2	27.95			1.8584		7.32		Break Area
-3	26.21			2.0067		1.40		
Ave		27.14	42.11		1.9334		4.27	Boron
828.511.5 -1	30.87			1.9044		-0.26		Break Area
-2	31.33			1.9164		-1.74		Break Area
-3	30.29			1.9452		-1.96		
-4	30.29			1.8458		3.25		
Ave		30.70	46.89		1.9030		-0.05	Glass
828.513.2 -1	29.27			1.8623		3.14		Break Area
-2	29.71			1.9090		0.38		Break Area
Ave		29.49	44.63		1.8857		1.76	Glass
828.517 -1	23.54			1.9203		4.53		
-2	25.28			1.8908		4.68		
-3	21.97			2.0242		0.64		
Ave		23.60	35.84		1.9451		3.28	Glass

TABLE XXVI (CONTINUED)
RESIN CONTENT, DENSITY, AND VOID CONTENT OF JOINT SPECIMENS

Property / Specimen No	Resin Content (% by wt.)		(% by vol.)		Density		Void Content (% by volume)		Comments
830-519-3 -1	20.68				1.9740		4.12		Break Area
-2	18.59				2.0570		1.81		Break Area
-3	18.16				2.0427		2.84		Break Area
Ave		19.14	31.10			2.0246		2.92	Glass
831-1-E -2	26.06				1.9562		0.78		
-3	25.48				1.9691		0.58		
-4	25.01				1.9795		0.42		
Ave		25.52	40.31			1.9683		0.59	Glass
831-501-D -1	22.23				1.9966		5.24		Break Area
-2	22.27				2.0127		4.45		Break Area
-3	22.58				1.9877		5.37		
Ave		22.36	35.87			1.9990		5.02	Boron
831-507-A -1A	24.58				2.0242		1.93		Break Area
-1B	24.47				2.0230		2.09		Break Area
-2	24.94				2.0140		2.12		
Ave		24.66	39.99			2.0204		2.05	Boron
831-509 -1A	28.03				1.9822		0.82		Break Area
-1B	28.19				1.9369		3.22		Break Area
-2	28.05				1.9638		1.72		
Ave		28.09	44.21			1.9610		1.92	Boron
832-1-C -2	25.73				1.9614		0.77		
-3	26.07				1.9547		0.84		
-4	25.93				1.9626		0.55		
Ave		25.91	41.69			1.9596		0.72	Glass
832-501-C -1A	23.00				1.9843		1.78		Break Area
-1B	21.89				2.0100		1.39		Break Area
-2	23.65				1.9924		0.86		
Ave		22.85	36.60			1.9956		1.34	Glass
832-503-B -1A	28.01				1.9266		0.77		Break Area
-1B	28.00				1.9165		1.30		Break Area
-2	28.10				1.9190		1.10		
Ave		28.04	44.73			1.9877		1.06	Glass
832-505-D -1A	21.83				2.0228		0.82		Break Area
-1B	21.97				2.0226		0.79		Break Area
-2	22.59				2.0144		0.62		
Ave		22.10	35.83			2.0199		0.74	Glass
832-507-E -1	23.78				2.0176		2.93		Break Area
-2	23.45				2.0240		2.91		Break Area
-3	24.06				2.0081		3.15		
Ave		23.77	38.47			2.0166		3.00	Boron
832-509-D -1A	26.93				1.9825		1.65		Break Area
-1B	24.80				2.0279		1.57		Break Area
-2	26.86				1.9915		1.61		
Ave		26.20	42.12			2.0029		1.61	Boron
832-511-D -1A	27.79				1.9758		1.60		Break Area
-1B	27.57				1.9847		1.10		Break Area
-2	27.96				1.9804		1.24		
Ave		27.77	44.17			1.9820		1.31	Boron
832-513-E -1A	26.24				2.0016		1.62		Break Area
-1B	26.81				1.9907		1.68		Break Area
-2	26.34				1.9942		1.91		
Ave		26.46	42.38			1.9955		1.74	Boron
833-1-E -2	23.72				1.9947		0.69		
-3	24.08				1.9841		0.93		
-4	24.66				1.9879		0.28		
Ave		24.15	38.55			1.9889		0.63	Glass
833-501-B -1A	19.99				2.0392		1.51		Break Area
-1B	19.70				2.0550		0.99		Break Area
-2	21.79				2.0246		0.76		
Ave		20.49	33.54			2.0396		1.09	Glass
833-503-E -1A	23.25				1.9891		1.34		Break Area
-1B	23.27				2.0058		0.50		Break Area
-2	23.70				1.9967		0.60		
Ave		23.41	37.52			1.9972		1.15	Glass
833-505-B -1A	26.69				1.9402		1.10		Break Area
-1B	26.78				1.9477		0.64		Break Area
-2	26.86				1.9480		0.56		
Ave		26.78	41.81			1.9453		0.77	Glass
833-507-E -1	22.44				2.0140		4.24		
-2	23.09				2.0068		4.03		Break Area
-3	23.04				1.9794		5.39		Break Area
Ave		22.86	36.70			2.0001		4.55	Boron
833-509-E -1A	23.63				1.9809		4.82		Break Area
-1B	21.84				1.9942		5.69		Break Area
-2	21.60				1.9918		6.00		
Ave		22.36	35.69			1.9890		5.50	Boron
833-511-D -1A	23.83				1.9948		3.99		Break Area
-1B	24.51				1.9877		3.76		Break Area
-2	24.45				1.9802		4.18		
Ave		24.26	38.70			1.9876		3.98	Boron
833-513-E -1A	22.57				1.9952		5.03		Break Area
-1B	22.82				2.0147		3.88		Break Area
-2	22.46				1.9988		4.95		
-2A	23.35				2.0055		1.51		
Ave		22.80	36.66			2.0036		3.84	Boron

TABLE XXVI (CONTINUED)
RESIN CONTENT, DENSITY, AND VOID CONTENT OF JOINT SPECIMENS

Property Specimen No.	Resin Content (% by wt.)		(% by vol.)	Density		Void Content (% by volume)		Comments
828-519.5 -1	24.08			1.9931		0.48		Break Area
-2	23.51			1.9725		1.96		Break Area
Ave		23.80	37.87		1.9828		1.22	Glass
828-525.1 -1	25.09			1.9908		3.12		Break Area
-2	25.42			1.9693		3.89		Break Area
-3	26.38			2.0060		1.29		
Ave		25.63	40.91		1.9887		2.77	Boron
828-529 -1	25.62			2.0287		0.83		
-2	26.81			1.9942		1.51		
-3	26.03			1.9872		2.51		
Ave		26.15			2.0034		1.62	Boron
828-537.1 -1	30.43			1.8850		1.09		
-2	30.30			1.8977		0.52		
-3	29.88			1.9081		0.29		
Ave		30.20	48.73		1.8976		0.63	Glass
828-537.4 -1	29.46			1.8935		1.38		Break Area
-2	29.39			1.8866		1.79		Break Area
-3	30.51			1.8743		1.59		
Ave		29.79	45.06		1.8848		1.59	Glass
828-539.1 -1	30.94			1.8719		1.39		
-2	30.80			1.8659		1.82		
-3	31.60			1.8745		0.77		
Ave		31.11	46.71		1.8708		1.33	Glass
829-1.2 -2	25.51			2.0184		1.43		
-3	25.21			2.0235		1.43		
-6	26.33			1.9912		2.06		Break Area
Ave		25.68	41.45		2.0110		1.64	Boron
829-501.3 -1A	26.53			2.0110		0.92		Break Area
-1B	26.74			1.9903		1.76		Break Area
-2	25.55			2.0064		1.97		
Ave		26.27	42.22		2.0026		1.55	Boron
829-505.3 -1A	27.40			1.9828		1.59		
-1B	27.33			1.9829		1.64		
-2	27.18			1.9846		1.68		
Ave		27.30	43.46		1.9834		1.64	Boron
829-507.3 -1A	27.51			1.9725		2.00		Break Area
-1B	27.23			1.9936		1.19		Break Area
-1	26.94			1.9950		1.36		
-2	26.82			1.9962		1.41		
-3	26.84			1.9894		1.73		
Ave		27.07	43.22		1.9893		1.54	Boron
829-511.1 -1	31.27			1.8792		0.76		
-2	31.61			1.8827		0.32		
-3	31.78			1.8825		0.20		
Ave		31.55	47.64		1.8815		0.43	Glass
829-513.2 -1A	31.42			1.8831		0.45		Break Area
-1B	31.28			1.8789		0.77		Break Area
-1	30.64			1.8757		1.42		
Ave		31.11	46.92		1.8792		0.88	Glass
829-517.2 -1A	29.78			1.8885		1.40		Break Area
-1	30.17			1.8863		1.07		
-2	30.30			1.8950		0.66		
Ave		30.15	45.73		1.8899		1.04	Glass
829-519.1 -1A	29.46			1.8921		1.45		Break Area
-1B	29.73			1.888		1.42		Break Area
-1	29.86			1.8812		1.68		
Ave		29.68	44.96		1.8876		1.52	Glass
829-519.3 -1A	31.49			1.8744		0.85		Break Area
-1B	31.68			1.8717		0.85		Break Area
-1	30.81			1.8828		0.92		
Ave		31.33	47.18		1.8763		0.87	Glass
830.1-3 -2	22.05			2.0202		4.28		
-3	21.64			2.0159		4.83		
-7	22.44			1.9879		3.26		
Ave		22.04	35.52		2.0080		4.12	Boron
830-501.1 -1	23.29			2.0009		4.15		
-2	23.71			1.9822		4.67		
-3	23.72			1.9755		5.00		
Ave		23.57	37.57		1.9862		4.61	Boron
830-507.1 -1	24.48			1.9281		6.67		Break Area
-2	24.96			2.0116		2.22		Break Area
-3	27.14			1.9659		2.64		Break Area
Ave		25.53	40.33		1.9685		3.84	Boron
830-511.5 -2	25.07			1.9846		0.15		
-3	25.02			1.9853		0.12		
-8	24.54			1.9333		3.11		Break Area
Ave		24.84	39.22		1.9675		1.13	Glass
830-513.5 -1	26.51			1.9180		2.37		Break Area
-2	25.11			1.8885		4.93		Break Area
-3	25.77			1.9187		2.90		Break Area
Ave		25.80	39.52		1.9084		3.40	Glass
830-517.1 -1	25.09			1.9573		1.48		Break Area
-2	22.69			1.9951		1.49		Break Area
-3	21.09			2.0315		1.00		
Ave		22.96	36.75		1.9946		1.32	Glass

TABLE XXVI (CONTINUED)
RESIN CONTENT, DENSITY, AND VOID CONTENT OF JOINT SPECIMENS

Property Specimen No.	Resin Content (% by wt.)		(% by vol.)	Density		Void Content (% by vol.)		Comments
833-515-F -1A	25.34			1.9893		2.99		Break Area
-1B	25.49			1.9921		2.72		Break Area
-2	25.78			1.9925		2.46		
Ave		25.54	40.82		1.9913		2.72	Boron
833-517-D -1A	23.63			1.9823		4.76		Break Area
-1B	24.15			2.0195		2.78		Break Area
-2	23.85			2.0015		3.65		
Ave		23.88	38.35		2.0011		3.73	Boron
833-519-4 -2	24.04			1.9721		1.56		Break Area
-5	25.88			1.9568		0.88		Break Area
-6	24.67			1.9716		1.09		
Ave		24.86	39.24		1.9668		1.18	Glass
833-521-2 -1	24.78			1.9704		4.37		Break Area
-2	24.89			2.0102		2.35		Break Area
-3	24.40			2.0272		1.94		
Ave		24.69	39.68		2.0026		2.89	Boron
834-1-E -2	24.37			1.9840		0.70		
-3	24.37			1.9890		0.45		
-4	24.23			1.9903		0.50		
Ave		24.32	38.80		1.9878		0.55	Glass
834-501-E -1A	22.75			2.0067		0.87		Break Area
-1B	23.78			1.9898		0.88		Break Area
-2	26.48			1.9479		0.87		
Ave		24.34	38.71		1.9815		0.87	Glass
834-503-B -1A	25.59			1.9591		1.00		Break Area
-1B	26.23			1.9530		0.80		Break Area
-2	26.82			1.9456		0.72		
Ave		26.21	41.07		1.9526		0.84	Glass
834-505-C -1A	23.96			1.9900		0.73		Break Area
-1B	23.65			1.9841		1.27		Break Area
-2	26.54			1.9416		1.14		
Ave		24.72	39.12		1.9719		1.05	Glass
834-507-C -1	24.33			2.0314		1.80		Break Area
-2	24.87			2.0216		1.81		Break Area
-3	25.50			2.0050		2.08		
Ave		24.90	40.35		2.0193		1.90	Boron
834-509-A -1A	23.51			2.0404		2.07		Break Area
-1B	23.98			2.0251		2.40		Break Area
-2	24.13			2.0197		2.53		
Ave		23.87			2.0284		2.33	Boron
834-511-D -1A	24.18			2.0129		2.81		Break Area
-1B	23.30			2.0120		3.61		Break Area
-2	23.10			1.9717		5.70		
Ave		23.53	37.75		1.9989		4.04	Boron
834-513-B -1A	25.90			2.0041		1.79		Break Area
-1B	25.45			2.0104		1.87		Break Area
-2	24.38			2.0036		3.10		
-3	25.01			1.9968		2.89		
Ave		25.19	40.51		2.0037		2.41	Boron
838-1-5 -1	24.21			1.9740		4.67		Break Area
-2	25.82			1.9276		5.60		Break Area
Ave		25.02	39.17		1.9508		5.15	Boron
838-501-3 -1	26.30			1.9709		3.09		Break Area
-2	24.66			2.0147		2.32		Break Area
Ave		25.48	40.75		1.9928		2.71	Boron
838-503-5 -1	25.33			2.0093		2.02		Break Area
-2	26.46			2.0006		1.49		Break Area
Ave		25.90	41.68		2.0050		1.76	Boron
838-505-3 -1	23.65			1.9129		8.07		Break Area
-2	22.89			1.9027		9.17		Break Area
Ave		23.27	35.63		1.9078		8.62 *	Boron
838-507-4 -1	22.74			1.9038		9.24		Break Area
-2	24.10			1.8850		9.06		Break Area
Ave		23.42	35.61		1.8944		9.15 *	Boron
838-509-5 -1	25.36			1.9212		6.29		Break Area
-2	25.34			1.9300		5.88		Break Area
-3			39.18					
Ave		25.35			1.9256		6.09 *	Boron
838-511-2 -1	28.84			1.8918		1.94		Break Area
-2	28.48			1.9205		0.73		Break Area
-3			43.85					
Ave		28.66			1.9062		1.34	Glass
838-513-4 -1	26.40			1.8153		7.67		Break Area
-2	27.08			1.9231		1.67		Break Area
-3	29.17			1.9011		1.2		
Ave		26.74	40.11		1.8692		4.67	Glass
838-515-3 -1	27.84			1.8361		5.56		Break Area
-2	30.09			1.8110		5.22		Break Area
-3	28.61			1.9100		1.17		
Ave		28.97	42.40		1.8236		5.39	Glass
838-517-4 -1	27.26			1.9461		0.36		Break Area
-2	27.56			1.9044		2.26		Break Area
-3	27.00			1.9450		0.61		
Ave		27.41	42.35		1.9253		1.31	Glass

*SEVERELY DAMAGED SPECIMENS

TABLE XXVI (CONTINUED)
RESIN CONTENT, DENSITY, AND VOID CONTENT OF JOINT SPECIMENS

Property / Specimen No	Resin Content (% by wt.)		(% by vol.)	Density		Void Content (% by vol.)		Comments
838.519.4 -1	28.33			1.8309		5.47		Break Area
-2	28.61			1.8695		3.27		Break Area
Ave		28.47	42.28		1.8502		4.37	Glass
838.521.5 -1	26.18			1.8188		7.65		Break Area
-2	27.24			1.8695		2.00		Break Area
-3	27.40			1.9217		1.39		
Ave		26.71	39.53		1.8442		4.83	Glass
839.1.5 -1	22.81			1.9011		9.31		Break Area
-2	22.88			1.9079		8.96		Break Area
-3			34.97					
Ave		22.85			1.9043		9.14	Boron
839.501.4 -1	27.72			1.9683		2.04		Break Area
-2	27.21			1.9663		2.56		Break Area
-3			43.37					
Ave		27.47			1.9673		2.30	Boron
839.503.5 -1	26.23			1.9273		5.29		Break Area
-2	22.60			1.9603		6.66		Break Area
-3	31.52			1.8215		6.43		
Ave		24.42	38.10		1.9438		5.96	Boron
839.505.3 -1	26.56			1.9905		1.92		Break Area
-2	23.54			2.0404		2.04		Break Area
-3	24.03			2.0223		2.49		
Ave		25.05	40.52		2.0155		1.98	Boron
839.507.4 -1	29.50			1.9483		1.57		Break Area
-2	28.37			1.9600		1.92		Break Area
-3			45.39					
Ave					1.9542		1.75	Boron
839.509.5 -1	21.55			1.9713		7.01		Break Area
-2	21.39			1.9693		7.23		Break Area
-3			33.95					
Ave		21.47			1.9703		7.12	Boron
839.511.4 -1	33.08			1.8567		0.61		Break Area
-2	32.75			1.8420		1.64		Break Area
-3	31.79			1.8512		1.86		
Ave		32.92	48.86		1.8494		1.13	Glass
839.513.4 -1	27.72			1.9044		1.88		Break Area
-2	27.84			1.8935		2.61		Break Area
-3			42.39					
Ave		27.78			1.9015		2.25	Glass
839.517.5 -1	27.02			1.9362		1.05		Break Area
-2	26.93			1.9341		1.22		Break Area
-3			41.90					
Ave		26.98			1.9352		1.14	Glass
839.519.4 -1	27.35			1.9219		1.52		Break Area
-2	27.68			1.9059		2.09		Break Area
-3			42.27					
Ave		27.52			1.9139		1.81	Glass
839.521.5 -1	28.74			1.8721		3.03		Break Area
-2	29.08			1.8743		2.66		Break Area
-3			43.46					
Ave		28.91			1.8732		2.85	Glass
843.1 -1	23.31			1.9906		4.62		
-2	23.40			2.0282		2.75		
-3	24.16			2.0043		3.25		
Ave		23.62	38.06		2.0077		3.54	Boron
843.501 -1	25.26			1.8409		10.28		
-2	24.99			1.8711		9.03		
-3	24.84			1.9345		6.07		
-4	25.25			1.8544		9.64		
Ave		25.09	37.66		1.8752		8.76 *	Boron
849.1.3 -1	26.16			2.0157		1.00		
-2	25.81			1.9885		2.63		
-3	25.66			1.9598		4.16		
-4	25.93			2.0040		1.77		
Ave		25.89	41.34		1.9920		2.39	Boron
849.501.3 -1	26.85			1.9147		2.27		
-2	26.53			1.9283		1.83		
-3	26.89			1.9154		2.20		
-4	25.41			1.9452		1.84		
Ave		26.42	40.84		1.9259		2.04	Glass
849.501.4 -1	21.47			2.0205		1.22		
-2	22.10			1.9947		1.98		
-3								
Ave		21.79	35.11		2.0076		1.60	Glass
849.503.2 -1	25.30			1.9920		2.89		
-2	26.20			1.9780		2.82		
-3	25.63			1.9848		2.96		
Ave		25.71	40.96		1.9849		2.89	Boron
849.503.3 -1	28.83			1.9493		2.07		
-2	29.18			1.9284		2.84		
Ave		29.01	45.14		1.9389		2.46	Boron
849.505.3 -1	26.83			1.9274		1.64		
-2	26.91			1.9181		2.05		
-3	26.26			1.9435		1.26		
-4	26.55			1.9231		2.07		
Ave		26.64	41.22		1.9280		1.76	Glass
849.505.4 -1	21.89			1.9106		6.27		
-2	23.35			1.9914		1.15		
Ave		22.62	35.42		1.9510		3.71	Glass

*SEVERELY DAMAGED SPECIMEN

TABLE XXVI (CONTINUED)
RESIN CONTENT, DENSITY, AND VOID CONTENT OF JOINT SPECIMENS

Property Specimen No.	Resin Content (% by wt.)		(% by vol.)		Density		Void Content (% by vol.)		Comments
849-507 -1	23.69				2.0124		3.26		
-2	24.49				1.9848		3.91		
-3	24.26				2.0020		3.28		
Ave		24.15	38.76			1.9997		3.48	Boron
849-509-2 -1	31.39				1.8629		1.53		
-2	31.70				1.8548		1.74		
-3	29.85				1.8889		1.32		
-4	30.05				1.8854		1.35		
Ave		30.75	46.22			1.8730		1.49	Glass
850-1-2 -1	27.22				1.9617		2.78		
-2	26.63				1.9848		2.13		
Ave		26.93	42.63			1.9733		2.46	Boron
850-501-3 -1	26.28				1.9775		2.78		
-2	25.23				1.9966		2.72		
-3	25.44				2.0070		2.04		
Ave		25.55	41.98			1.9957		2.51	Boron
850-501-4 -1	25.75				2.0003		2.10		
-2	25.55				2.0022		2.18		
Ave		25.65	41.20			2.0013		2.14	Boron
850-503-3 -1	24.85				1.9663		1.21		
-2	24.71				1.9584		1.72		
Ave		24.78	39.03			1.9624		1.47	Glass
850-503-4 -1	25.20				1.9561		1.45		
-2	25.08				1.9694		0.88		
-3	25.54				1.9645		0.77		
Ave		25.27	39.82			1.9633		1.03	Glass
850-505-3 -1	22.58				2.0141		0.64		
-2	23.16				1.9893		1.40		
-3	22.83				1.9971		1.28		
Ave		22.86	36.70			2.002		1.11	Glass
850-505-5 -1	22.49				1.9829		2.25		
-2	21.50				2.0266		0.89		
Ave		22.00	35.40			2.0048		1.57	Glass
851-1-3 -1	23.33				2.0179		3.30		
-2	23.85				1.9962		3.90		
Ave		23.59	38.00			2.0071		3.60	Boron
851-1-1-4 -1	26.26				2.0045		1.47		
-2	25.64				1.9832		3.04		
-3	26.93				1.9890		1.67		
Ave		26.28	42.02			1.9922		2.06	Boron
851-503-4 -1	26.45				1.9019		6.36		
-2	26.10				1.9176		5.87		
Ave		26.28	40.28			1.9098		6.12	Boron
851-505-2 -1	27.28				1.8686		4.31		
-2	26.32				1.9346		1.67		
Ave		26.80	40.90			1.9016		2.99	Glass
852-503-2B -1	28.00				1.9770		1.37		
-2	28.40				1.9682		1.48		
-3	28.38				1.9637		1.72		
Ave		28.26	44.67			1.9696		1.52	Boron
852-505 -1	20.37				2.0346		1.43		
-2	19.75				2.0455		1.40		
-3	19.84				2.0470		1.26		
Ave		19.99	32.77			2.0424		1.36	Glass
852-507-2 -1	27.96				1.9753		1.49		
-2	28.50				1.9630		1.65		
-3	29.20				1.9619		1.38		
Ave		28.45	44.91			1.9667		1.51	Boron
852-511 -1	25.18				2.0250		1.38		
-2	26.14				1.9965		1.95		
-3	23.99				2.0337		1.97		
Ave		25.10	40.66			2.0184		1.77	Boron
852-511 -1	25.04				1.9732		4.04		
-2	21.54				1.9585		7.56		
-3	25.17				1.9860		3.28		
Ave		23.92	37.87			1.9726		4.96	Boron
852-513 -1	24.13				1.9887		0.66		
-2	23.80				1.9932		0.70		
-3	24.02				1.9710		1.64		
Ave		23.98	38.19			1.9843		1.00	Glass
854-1-1 -1	23.37				1.9756		5.29		Break Area
-2	23.83				1.9543		4.01		Break Area
-3	20.84				2.0106		5.76		
Ave		22.68	36.29			1.9935		5.02	Boron
854-501-1 -1	24.04				2.0031		3.41		Break Area
-2	23.49				2.0053		3.77		Break Area
-3	24.65				2.0218		1.99		
Ave		24.06	38.81			2.0101		3.06	Boron
854-503-1 -1	24.37				2.0146		2.58		Break Area
-2	23.51				2.0053		3.75		Break Area
-3	24.42				1.9868		3.88		
Ave		24.10	38.73			2.0022		3.40	Boron
854-505-1 -1	23.39				1.9814		5.00		Break Area
-2	23.19				1.9732		5.56		Break Area
-3	23.47				1.9863		4.70		
Ave		23.35	37.11			1.9803		5.09	Boron
854-507-5 -1	22.81				1.9563		6.66		Break Area
-2	23.21				1.9885		4.81		Break Area
-3	23.45				1.9872		4.67		
Ave		23.16	36.76			1.9775		5.38	Boron

TABLE XXVI (CONCLUDED)
RESIN CONTENT, DENSITY, AND VOID CONTENT OF JOINT SPECIMENS

Property / Specimen No.	Resin Content (% by wt.)		Resin Content (% by vol.)		Density		Void Content (% by vol.)		Comments
854-511-1 -1	17.15			2.0866		1.59		Break Area
-2	16.51			2.0947		1.75		Break Area
-3	16.17			2.0774		2.85		
Ave		16.61	27.81		2.0862		2.06	Glass
854-513.1 -1	16.59			2.0705		2.82		Break Area
-2	16.65			2.0922		1.75		Break Area
-3	16.80			2.0944		1.52		
Ave		16.68	27.92		2.0857		2.03	Glass
854-517.2 -1	18.29			2.0615		1.84		Break Area
-2	20.14			2.0475		1.00		Break Area
-3	20.02			2.0481		1.06		
Ave		19.48	32.09		2.0524		1.30	Glass
854-519-2 -1	18.90			2.0193		3.36		
-2	19.71			2.0243		2.46		Break Area
-3	18.26			2.0696		1.48		
Ave		18.96	31.01		2.0377		2.43	Glass
855-1 -1	27.48			1.9752		1.83		
-2	26.58			1.9979		1.50		
-3	26.67			1.9841		2.18		
Ave		26.91	42.89		1.9857		1.84	Boron
855-1 -1	27.49			1.9757		1.86		
-2	26.26			2.0064		1.37		
-3	26.76			1.9883		1.84		
Ave		26.84	42.87		1.9901		1.69	Boron
855-501 -1	24.65			1.9522		2.00		
-2	22.46			2.0110		0.86		
-3	22.93			2.0020		0.90		
Ave		23.35	37.26		1.9884		1.25	Glass
855-501 -1	21.45			2.0019		2.15		
-2	24.86			1.9690		1.07		
-3	21.18			2.0218		1.39		
Ave		22.50	36.07		1.9976		1.54	Glass
856-1-2 -1	27.69			1.9799		1.65		Break Area
-2	27.90			1.9567		2.46		Break Area
-3	27.66			1.9815		1.43		
Ave		27.68	43.82		1.9727		1.85	Boron
856-501-2 -1	27.12			1.9828		1.82		Break Area
-2	27.21			1.9860		1.58		Break Area
-3	27.39			1.9814		1.66		
Ave		27.24	43.36		1.9834		1.69	Boron
856-507-2 -1	27.95			1.9754		1.23		Break Area
-2	28.12			1.9751		1.37		Break Area
-3	28.17			1.9788		1.14		
Ave		28.08	44.54		1.9764		1.25	Boron
856-511-2 -1	23.61			1.9909		0.97		Break Area
-2	24.10			1.9713		1.56		Break Area
-3	23.33			1.9916		1.15		
Ave		23.68	37.72		1.9846		1.23	Glass
856-513.3 -1	25.81			1.9602		0.77		Break Area
-2	25.47			1.9586		1.11		Break Area
-3	24.33			1.9819		0.84		
Ave		25.20	39.78		1.9669		0.91	Glass
856-517-1 -1	26.80			1.9386		1.09		Break Area
-2	26.45			1.9461		0.98		Break Area
-3	25.36			1.9659		0.83		
Ave		26.20	41.01		1.9502		0.97	Glass
856-519-1 -1	23.47			1.9785		1.70		Break Area
-2	24.01			1.9898		0.70		Break Area
-3	22.78			2.0131		0.53		
Ave		23.42	37.48		1.9938		0.98	Glass

SECTION IV
REFERENCES

REFERENCES

1. Toellner, H.M. "Method for Determination of Resin Content of Boron Epoxy Laminates," McDonnell Douglas Report LR-DAD-3817, 23 April 1968.

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13 ABSTRACT Engineering drawings, experimental data, and quality control data are presented in this volume for specimens that were tested in an investigation of joints and attachments in advanced fibrous composites for aircraft structures. Engineering drawings are presented showing design details and parametric variations for each specimen. Test fixture and instrumentation details are shown for a torsion ring adhesive shear test apparatus designed to measure stress-strain characteristics of adhesives in pure shear without the stress concentrations of conventional lap shear specimens. Experimental plots or test data tabulations are presented for basic laminate and adhesive properties and for static and fatigue strength tests on bonded and bolted joint specimens. Laminate properties are presented for boron and fiber glass-reinforced epoxy resin composites under tension, compression, in-plane shear, interlaminar shear, and pin-bearing loads. Test results are summarized for six adhesives in lap joint shear, flatwise tension on a honeycomb core, and in pure shear in the torsion ring test. Static test results are given for adhesive joint specimens (single and double lap, scarf, stepped lap, and variable stiffness) using Shell 951 adhesive (and AF130 in selected joints), and for single-fastener, bolted joint specimens (single and double lap, composite-reinforced steel shim-reinforced, and bushed hole) using 0.19- or 0.250-inch-diameter bolts. Test results are tabulated for selected joint concepts under constant-amplitude fatigue test conditions. Quality control specifications, incoming inspection records, and resin and void content determinations are presented. The vacuum pyrolysis method of determining the resin content by boron-epoxy laminates is described.

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	ROLE	WT	ROLE	WT	ROLE	WT
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